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United States Department of the Interior
Bureau of Land Management
Butte District

State of Montana
Department of Environmental Quality

November 1997

Volume I
Draft Environmental Impact Statement
Golden Sunlight Mine

COOPERATING AGENCIES:

Montana Department of Natural Resources and Conservation
U.S. Army Corps of Engineers

79-031941

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BLM MISSION STATEMENT

The Bureau of Land Management is responsible for the stewardship of our public lands. It is committed to manage, protect, and improve these lands in a manner to serve the needs of the American people for all times.

Management is based upon the principles of multiple use and sustained yield of our nation's resources within a framework of environmental responsibility and scientific technology. These resources include recreation, rangelands, timber, minerals, watershed, fish and wildlife, wilderness, air and scenic, scientific, and cultural values.

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State of Montana
Department of Environmental Quality
PO Box 200901
Helena MT 59620-0901

U.S. Department of the Interior
Bureau of Land Management
Headwaters Resource Area
PO Box 3388
Butte MT 59702

November 1997

Dear Reader:

Enclosed for your review and comment is the Draft Environmental Impact Statement (EIS) for the Golden Sunlight Mine.

Golden Sunlight Mines, Inc., has applied to the Montana Department of Environmental Quality (MDEQ) and the U.S. Bureau of Land Management (BLM) for an amendment to its mine Operating Permit No. 00065. The proposed action would allow continued mining of gold ore and an expansion of the present open pit mine near Whitehall. The Draft EIS analyzes the potential impacts of the proposed action as well as the potential impacts of alternatives: 1) No Action; 2) Return Diversion; 3) Divided Dump; 4) 3:1 Slope; 5) No Pit Pond; and 6) Partial Backfill. The Draft EIS addresses issues and concerns raised during the public scoping period of September 28, 1995, to November 10, 1995, and during the public scoping meeting held in Whitehall on October 17, 1995. The operating permit amendment application is available for review at the MDEQ office in Helena and at the BLM office in Butte.

MDEQ and BLM have selected the Proposed Action as modified by the Return Diversion and No Pit Pond alternatives as the preliminary preferred alternative. **This is not a final decision.** The preferred alternative could change in response to public comment on the Draft EIS, new information, or new analysis that might be needed in preparing the Final EIS.

Public comments concerning the adequacy and accuracy of the Draft EIS will be accepted for 60 days, until January 21, 1998. Written comments may be sent to the Montana Department of Environmental Quality, Impact Assessment Bureau, P.O. Box 200901, Helena MT 59620-0901, attn: Greg Hallsten.

A public hearing to receive verbal and written comments will be held during the 60-day comment period. You will be notified of the date, time, and location.

Since the Final EIS might only contain public comments and responses, and changes to the Draft EIS, please keep this Draft EIS for future reference.

Mark A. Simonich

Mark A. Simonich, Director
State of Montana
Department of Environmental Quality

Merle Good

Merle Good, Area Manager
Bureau of Land Management
Headwaters Resource Area

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Draft
Environmental Impact Statement

Golden Sunlight Mine Expansion
Jefferson County, Montana

November 1997

Lead Agencies: State of Montana, Department of Environmental Quality and United States Department of the Interior, Bureau of Land Management, Headwaters Resource Area.

Cooperating Agencies: United States Army Corps of Engineers and State of Montana, Department of Natural Resources and Conservation.

Contacts for Further Information: Greg Hallsten, Montana Department of Environmental Quality, PO Box 200901, Helena MT 59620-0901 (406-444-3276) and David Williams, Bureau of Land Management, PO Box 3388, Butte MT 59702 (406-494-5059).

Abstract: This Draft EIS analyzes impacts associated with the implementation of Amendment 008 to Operating Permit No. 00065 and the extension of mine life through 2008 of the Golden Sunlight Mine near Whitehall, Montana. The Draft EIS analyzes seven alternatives, including the No Action Alternative and the company's Proposed Action. Significant issues include: acid rock drainage, groundwater and surface water quality, waste rock dump slope angle and dump reclamation success, pit reclamation, and perpetual water treatment. The preferred alternative at this time is the Proposed Action as modified by the Return Diversion and No Pit Pond alternatives. This alternative would allow continued mining while reducing or avoiding environmental impacts.

Other Environmental Review: This Draft EIS also will serve as the environmental review document for a permit issued by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act. The Montana Department of Natural Resources and Conservation will use information in this review for permitting actions concerning state-owned land and minerals.

Dates: Written comments on the Draft EIS will be accepted for 60 days (until January 21, 1998) following the date the Environmental Protection Agency publishes the Notice of Filing of the draft in the Federal Register.

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SUMMARY

PURPOSE AND NEED

Golden Sunlight Mines, Inc. (GSM) mines and processes gold-bearing ore on public and private lands near Whitehall, Montana under Operating Permit No. 00065 administered by the Montana Department of Environmental Quality (MDEQ) and the United States Department of Interior's Bureau of Land Management (BLM). This Environmental Impact Statement (EIS) addresses a 1994 Montana District Court decision that requires preparation of an EIS to evaluate the environmental effects of implementing Amendment 008 to Operating Permit No. 00065.

On September 1, 1994, a Montana District Court ruled that the Montana Department of State Lands (MDSL) improperly evaluated the potential for significant environmental impacts that could result from the implementation of Amendment 008, and that an EIS must be prepared to further evaluate these impacts. On February 7, 1995, a settlement agreement was reached that allowed mining to continue until the EIS was completed.

On July 1, 1995, MDSL was terminated by legislative action and its mine land reclamation regulatory functions were assumed by the newly created Montana Department of Environmental Quality (MDEQ). The new MDEQ assumed MDSL's responsibility for preparing an EIS for Amendment 008.

In addition to evaluating the potential impacts from implementation of Amendment 008, this EIS also evaluates a 1995 proposal by GSM to further amend its Operating Permit to extend the life of active mining through approximately 2006. This EIS thoroughly investigates the environmental impacts associated with the issues raised by the 1994 District Court decision, as well as the environmental impacts associated with continued mining through 2006.

ALTERNATIVES

No Action

Under the No Action Alternative, mining would cease when currently permitted waste rock dump space is filled. No new construction or expansion of the pit, waste rock dumps, process facilities, or tailings impoundments would occur. Current mining operations would cease, and all facilities would be reclaimed using the existing reclamation plan.

Proposed Action

The Proposed Action would allow continued operation of the mine site beyond its current permit boundaries. MDEQ and BLM would approve a new amendment to GSM's existing Operating Permit to allow mining to continue until approximately 2006. The Proposed Action would expand the pit, waste rock dump areas, and buttress area. Sheep Rock Creek would be diverted into a tributary of Conrow Creek to prevent water from contacting acid generating waste rock.

Under the Proposed Action, the mine's permit boundary would expand to include an additional 1,054 acres (631 acres of GSM-owned land, 323 acres of BLM administered land, and 100 acres of state school trust land administered by the Montana Department of Natural Resources and Conservation [MDNRC]). Disturbances associated with mining activities would expand to include an additional 627 acres (517 acres of GSM-owned land, 75 acres of BLM-administered land, and 35 acres of state school trust land). Ore tonnage processed under the Proposed Action would be 55 million tons, as compared to approximately 34.1 million tons processed through completion of currently permitted mining activities.

The reclamation plan under the Proposed Action differs from the current reclamation plan with respect to the size of the surface disturbance requiring reclamation, the capping material required for reclaiming the tailings impoundment, and the reclamation schedule.

Return Diversion Alternative

This alternative is a modification of the Proposed Action that would avoid potential impacts to the Conrow Creek drainage. Under the Proposed Action, a diversion channel would divert flows from Sheep Rock Creek into the Conrow Creek drainage. The increased flows in the Conrow Creek drainage have the potential to cause increased erosion and channel morphology changes in Conrow Creek and one of its tributaries. Under the Return Diversion Alternative, Sheep Rock Creek would be diverted around the East Waste Rock Dump and would reconnect with its natural drainage south of the dump, thereby avoiding the Conrow Creek drainage. Construction of the diversion channel would result in an additional 2.5 acres of disturbance as compared to the Proposed Action.

Divided Dump Alternative

This alternative is a modification of the Proposed Action that would avoid potential impacts to the Conrow Creek drainage and avoid permanent placement of waste rock in the Sheep Rock Creek drainage channel. The Divided Dump Alternative eliminates the need to place waste rock in Sheep Rock Creek by providing alternative options for waste rock disposal. Under this alternative, the East Waste Rock Dump capacity would be reduced by approximately 63 million tons as compared to the Proposed Action. This lost capacity would be recovered by distributing waste rock into several alternative areas. New disturbance areas would vary between a minimum scenario of 407 acres and a maximum scenario of 600 acres, depending on the areas selected for waste rock disposal (approximately 27 to 220 acres less disturbance than under the Proposed Action). There would be no need to divert Sheep Rock Creek into the Conrow Creek drainage to prevent water from contacting acid-generating waste rock because no waste rock would be placed in Sheep Rock Creek.

3:1 Slope Alternative

This alternative addresses concerns raised in the Court Order and Settlement Agreement regarding the feasibility of reclaiming 2:1 waste rock slopes. Under the 3:1 Slope Alternative, additional slopes would be graded to 3:1 (rather than 2:1) prior to revegetation. This alternative could be selected by the agencies as a reclamation option for either the No Action Alternative or the Proposed Action. By reducing slopes to 3:1, the east and west waste rock dumps would be 92 and 22 acres larger, respectively, than under the Proposed Action, resulting in an additional 114 acres of surface disturbance as compared to the Proposed Action.

No Pit Pond Alternative

This alternative addresses potential wildlife impacts that could result from allowing poor quality water to accumulate in the pit. No water would be allowed to pond in the pit bottom under this alternative. Final design at the completion of mining would provide for an underground sump to collect water that enters the pit. Water collected in the sump would be pumped to a permanent water treatment plant as needed. This alternative could be selected by the agencies as a reclamation option for either the No Action Alternative or the Proposed Action.

Partial Backfill Alternative

This alternative addresses concerns raised in the Court Order and Settlement Agreement regarding the feasibility of reclaiming the pit under the Montana Metal Mine Reclamation Act (MMRA). Under the Proposed Action, approximately 19 acres of pit benches would be capped with 24 inches of oxidized waste rock followed by 24 inches of soil and revegetated. Under the Partial Backfill Alternative, approximately 254 acres of the pit would be capped with 24 inches of oxidized waste rock followed by 24 inches of soil and revegetated. All acid-producing rock within the pit would be capped with oxidized waste rock. All other aspects of mine reclamation would be the same as those described for the Proposed Action. This alternative could be selected by the agencies as a reclamation option for either the No Action Alternative or the Proposed Action.

STIPULATION COMPLIANCE

The September 1, 1994, Montana District Court Ruling concluded that it was improper for MDEQ to base its approval of Amendment 008 on mitigation measures that were neither included or evaluated in MDEQ's 1990 Environmental Assessment (EA) for Amendment 008. As required by the February 7, 1995, Settlement Agreement, MDEQ has evaluated in this EIS the effectiveness of the 31 stipulations that were attached to MDEQ's Record of Decision (ROD) for Amendment 008. The substantive provisions contained in the 31 stipulations have been incorporated into GSM's Operating Permit and 1995 Permit Application and are evaluated in this EIS in the analysis of the existing and proposed reclamation plans. Please refer to the complete EIS for more detailed information on the evaluation of the 31 Stipulations. The results of the agencies' evaluation of the 31 stipulations are summarized below.

Stipulation No. 1: *All portions of waste rock dumps not needed for vehicular traffic and not proposed for future slope reduction must be reclaimed concurrent with ongoing activities.*

Concurrent reclamation is underway in areas that will not be reactivated for future mining or reclamation activity. To date, over 118 acres have been reclaimed. Reclamation, including waste rock dump slope reduction, oxidized waste rock capping, soil placement, and revegetation was initiated in 1995 for portions of the East and South Waste Rock Dumps.

This stipulation has been successful in instituting concurrent reclamation at the Golden Sunlight Mine project area. Concurrent reclamation has been initiated on-site and the commitment to future concurrent reclamation is outlined in both the existing and proposed reclamation plans.

Stipulation No. 2: *Research and monitoring plans must be developed, in consultation with the MDEQ and the BLM, in order to determine the effectiveness of the waste rock dump top reclamation described in Stipulation No. 1. The research and monitoring plan must include consideration of parameters that affect oxidation of pyrite and particularly acid drainage from the waste rock dumps. This plan must include and evaluate water balance, taking into consideration the effect of the rock cap and soil layers and the movement of water and oxygen into the reclaimed waste rock* *dumps. These plans must be submitted for final approval with the Annual Report to be submitted June 27, 1991, hereinafter referred to as the 1991 Annual Report.*

Research and monitoring plans to determine the effectiveness of waste rock dump top reclamation have been developed and implemented in consultation with MDEQ and BLM. As originally described in the Annual Report submitted in June 1991, the reclamation test plot program on the high-grade waste rock dump includes a reclaimed dump top test plot. This plot has been evaluated for all of the parameters listed in this stipulation, including infiltration, acidification, and water balance. A description of the test plot and monitoring plan was provided in the Annual Report submitted in March of 1992. A monitoring report is provided in the 1993 and subsequent annual reports.

The test plot studies were designed to provide information related to 2H:1V slope waste rock dump hydrology in light of applied revegetation techniques, as well as grade control factors, capping techniques, and revegetation performance on a variety of slope angles. The capping techniques and waste rock sampling procedures, as well as the oxide cap characteristic criteria proposed as a part of the current reclamation plan, were developed as a result of these studies.

Through 1994, sedimentation rates on the test plots were statistically comparable to natural rates from reference areas, with all rates under a tolerance level of 1.0 ton per acre per year. Similarly, vegetation cover was measured on 2H:1V slopes and found to have exceeded that of reference areas and to have surpassed the vegetation success criteria established for this project. Adjunct modeling using the Revised Universal Soil Loss Equation (RUSLE) as part of the EIS analysis showed that erosion could be held to acceptable levels on slopes up to 2H:1V if soils with the appropriate characteristics are reapplied to the slope surface. Additionally, three separate modeling approaches were used to provide an estimated water balance within the waste rock dumps (HELP; SOILCOVER; and an in-house model by Schafer and Associates, Inc.).

These test plot studies and modeling results predict that 2H:1V slopes can be successfully revegetated using the proposed steep slope reclamation techniques developed for this project (capping, contour benching, dozer gouging, mulching, intensive material sampling, etc.), and that infiltration through the reclaimed waste rock dump surface will be limited to 0.25 to 0.5 inch per year. The oxidation of pyrite is still expected to occur within the waste rock dumps, but the amount of moisture penetrating through the reclamation cap and migrating through the interior of the waste rock dumps is expected to be minimized by the design of the reclamation cap. To avoid long-term impacts to groundwater quality, a long-term groundwater monitoring and treatment plan has been developed and is described in this EIS.

Stipulation No. 2: GSM must construct drainage or seepage control structures in the foundation beneath the waste rock dumps, made of calcareous subsoils and constructed on the contours of the slopes. As-builts must be submitted with the annual reports.

Retention berm construction at the toe of the waste rock dumps has been ongoing since 1990 and continues concurrent with soil stripping. As-builts are submitted with the annual reports. Berms are constructed of *in situ* calcareous subsoils where available. Where possible, they are constructed on contour; however, much of the dump terrain to date has been too steep to allow contour berming. In steep areas, large berms are constructed across the natural drainages. Retention berms have been constructed by dozers and scrapers to a minimal height of six feet.

Retention berms were constructed beneath portions of the West Waste Rock Dump and East Waste Rock Dump in 1993. The berms were constructed in accordance with the plans shown in the Annual Report submitted in March 1992. Plans for as-built construction and planned retention berms are presented in the 1993 Annual Report.

These berms are designed to control seepage by capturing seepage at the toe of the waste rock dumps and promoting the infiltration of seepage into subsoils. With the exception of the pre-existing Midas Spring, no seepage has been documented at the toe of the waste rock dumps to date. The design of these structures should be sufficient to control infiltration through the waste rock dumps that could seep from the toe of the dumps. Any seepage reporting to the berms will contact colluvial materials and flow a very short distance before infiltrating in the colluvium.

Stipulation No. 4: GSM must design and construct an engineered diversion capable of handling a 100-year, 24-hour precipitation event around the tops of the reclaimed waste rock dumps and off the tops of the reclaimed waste rock dumps. Diversion designs must be submitted with the 1991 Annual Report. As-builts must be submitted with the annual report submitted following construction.

The design of the diversion channel system to direct surface storm water runoff around and off of the tops of the reclaimed waste rock dumps was supplied in the Annual Report submitted in March 1992. The design of the diversion channels around the tops of reclaimed dumps and off the tops of reclaimed dumps are adequate to handle a 100-year, 24-hour precipitation event. Implementation of the design will take place during final reclamation of each waste rock dump.

Stipulation No. 5: GSM must evaluate and report the acid-producing potential characteristics of the waste rock dump surface after slope reduction. A sampling density must be developed from waste rock dump test plots to be initiated in 1990-1991. GSM must layer or incorporate lime amendments (such as limestone), if necessary, on or into the waste rock dump surface, basing the amount needed on the neutralization requirements of the top 0.5 feet of waste rock, and basing the method of layering or incorporation on field testing initiated in 1990-1991.

GSM began testing the acid-producing potential characteristics and lime requirements of the oxidized waste rock cap on test plots in 1991. After reducing the slopes of the waste rock dumps and recontouring the surface, the new waste rock dump surface is tested for potential acid generation by analyzing composite sample taken from a survey controlled 100- X 100-foot grid established on the recontoured surface. The grid is established to verify thickness uniformity of reclamation cover layers. The number of samples tested for acidity is determined by the compositional variability observed in the waste rock dump material. Samples are submitted for either the modified Sobek method of acid-base accounting, or a on-site hydrogen peroxide based NAG pH test. If an on-site NAG pH testing method is used, a minimum number of 1 sample in 50 is verified with the modified Sobek method.

If samples have an acid-base accounting value using the modified Sobek method of >-20 and/or a NAG pH of <3.2, then the upper 6 inches of the dump is limed to neutrality before a 24-inch-thick minimum cap of suitable or limed oxidized waste rock or borrow material is placed on the dump surface. GSM has the option of placing an additional 6 inches of oxidized waste rock or borrow material in the reclamation cap, in lieu of the liming requirement for the upper 6 inches of the acid waste rock dump surface.

Placement of oxidized capping material must meet uniformity criteria established by MDEQ and BLM. After the oxidized cap is in place, the survey grid with 100- X 100-foot spacing is reestablished on the dump, and samples are collected again at each grid intersection. The samples are visually examined, and representative samples are tested. Grid areas with more than one sample having a NAG pH of less than 4.0 are either top-dressed with enough lime to neutralize the cap, or are recapped with suitable oxide rock.

This waste rock dump surface sampling and analysis program appears to offer a reliable means of testing the success of capping efforts and of assessing the acid-producing potential of material within the plant root zone. Media sampling intensity and analysis methods conform to, or exceed, acceptable standards or have been developed specifically to address site conditions. Parameter analysis values selected to indicate that a mitigation action (such as lime amendments) be taken are within acceptable limits. To date, the sampling and analysis methodologies have contributed to an acceptable level of revegetation success at the Golden Sunlight Mine site.

Stipulation No. 6:* *GSM must evaluate and report the acid-producing potential characteristics and lime requirements of the oxidized waste rock cap during placement. The sampling density, the amounts of lime needed, and the method of incorporation of lime (to neutralize the acid-production potential) must be based on field testing initiated on the oxidized waste rock that is used on the dump test plots in 1989-1991.

GSM's test plots have helped determine the amount of lime needed for oxide capping. GSM also began kinetic testing of cap rock materials with acid-base account values in the 0 to -20 range in 1992 and continued testing in 1993, as described in Appendix AR-93-K of the 1993 Annual Report. A final summary report on all waste rock dump research is provided in Appendix 5.5-1 of GSM's 1995 Permit Application (GSM 1995b).

The sampling and liming plan is provided in GSM's Operating Permit. Samples collected to date are summarized in Appendix AR-98-1.3 of the 1998 Annual Report. The oxidized rock planned for use as capping material is sampled for potential acidity prior to placement according to the procedure described for Stipulation No. 5. If sampled oxidized rock has lime requirements of 0 or more tons lime per 1,000 tons material, it is limed to neutrality.

After the oxidized rock cap is in place, the 100- X 100-foot grid is re-established and samples are collected at each point. The samples are visually examined, and representative samples analyzed for potential acidity. If potentially acidic areas are identified, more samples are submitted. Those grid areas where more than one sample has identified lime rates greater than 0 tons lime per 1,000 tons material will either be top dressed with enough lime to neutralize the cap, or recapped with suitable oxidized rock.

As noted for Stipulation No. 5, the waste rock dump surface sampling and analysis program developed by GSM appears to offer a reliable means of assessing the acid-producing potential of material proposed for use as a rock cap. Rock cap material sampling intensity and analysis methods conform to acceptable standards.

Stipulation No. 7: GSM must sample soil after placement on re-contoured waste rock dumps. The sampling density and parameters to be measured must be determined in consultation with the agencies. The purpose of the sampling is to identify physical or chemical limitations inherent in the soils, which must be minimized, and to identify areas where more extensive erosion control measures may be needed to minimize surface soil loss or mass slippage of soils on slopes.

The cover soil sampling plan was given in Appendix D of the Annual Report submitted in March 1992. After placement, one cover soil sample is collected every five to ten acres. Samples are analyzed for texture, pH, electrical conductivity, sodium adsorption ratio, potential acidity, water holding capacity, and plant nutrients. This data is used to identify whether highly erodible soils are present. Samples collected to date are summarized in Appendix AR-95-1.3 of the 1995 Annual Report.

A density of one soil sample per 5 to 10 acres allows for an adequate evaluation of the characteristics of replaced soils in terms of both physical and chemical characteristics related to the potential for erosion. Assuming this sampling plan is combined with visual erosion inspection monitoring, the plan is considered to be an effective means of identifying where additional erosion control measures may be needed on contoured waste rock dump slopes.

Mitigation Measure S-1 has been developed to provide for continued monitoring, testing, and restabilization of soils affected by steam venting. Standards and guidelines are provided to identify when stabilization efforts will be required. This measure would be an effective means of assessing and mitigating any soil and vegetation changes occurring as a result of steam venting.

Stipulation No. 8: GSM must design erosion control systems including diversions for the waste rock dump, to be submitted in the 1991 Annual Report, which minimize soil loss off steep, long waste rock dump slopes. GSM must monitor erosion rates to validate the effectiveness of proposed benching or other slope breaks in minimizing total effective slope length.

Erosion control system designs, including storm water runoff diversions for the waste rock dump slopes, were completed in conjunction with designs for storm water runoff diversions around and off the dump tops (see Stipulation No. 4). These designs were described in the Annual Report submitted in March 1992.

An additional cross-section requested by the agencies was included in the Annual Report submitted in March 1993. This cross-section showed the slopes that will be placed on waste rock dump tops to allow water to flow into the diversion structures. The cross-section also showed typical distances between diversion structures on the dump slopes and details of the access roads to service the diversions.

Erosion troughs have been in place below the high-grade waste rock dump reclamation test plots since 1991. Four additional erosion troughs were constructed in the West Waste Rock Dump reclamation test plots in 1994. Summary reports on erosion rates of test plots are provided in Appendices 5.5-1 and 5.5-2 of GSM's 1995 Permit Application (GSM 1995b).

The erosion troughs currently in place indicate that the majority of erosion occurs as sheet erosion. They also have shown that the staggered dozer gouges constructed on the slopes are effective in reducing initial sheet erosion prior to the establishment of vegetation. The calculated erosion rates are significantly less than one ton per acre per year, indicating that sheet erosion should not be a long-term concern.

Stipulation No. 9: Based on GSM's current re-evaluation of waste rock dump design and placement, which is being done in order to 1) minimize ultimate slope reduction, 2) increase benching and other slope length breaks, 3) control runoff from major storm events and 4) relocate soils and oxidized waste rock stockpiles, GSM must submit a revised dumping plan for agency approval in the 1991 Annual Report. The plan must include a revised schedule for decommissioning and concurrent reclamation of the waste rock dumps during mine life.

The revised dumping plan and redesigned dumps were described in the Annual Report submitted in March 1992. The plan focuses on minimizing disturbance and soil erosion. The redesign work also has minimized ultimate slope reduction and increased benching. GSM supplies volumes of oxide rock and soil salvage in GSM's Annual Reports. This information is being provided annually. Current waste rock dump plans can be found in Chapter II of GSM's Operating Permit. Current soil and oxide salvage volumes can be found in the 1996 Annual Report.

The revised waste rock dump plans have accomplished the four goals outlined above and are the basis of the EIS evaluations of waste rock dumps. The revised waste rock dump plans are incorporated into the EIS in the detailed analysis of waste rock dump stability, erosion, infiltration, and reclamation.

Stipulation No. 10: GSM must evaluate methods, for the 1991 Annual Report, of minimizing movement of acidic water to the face of the cycloned sands portion of the embankment face of the reclaimed dike. One of the methods evaluated must be application of a wedge of net-neutralizing material composed of either waste rock or calcareous borrow material to the front face of the cycloned sands portion of the embankment face in order to construct an overall slope of 3H:1V on the embankment face. The material must be 24 inches deep at the crest of the embankment and increase in depth down the embankment face.

GSM evaluated the wedge, and found that it would not further minimize movement of water to the embankment face. In the Annual Report submitted in June 1991, GSM documented that the depositional angle of the cyclone sands is near 3H:1V or flatter. Also, in-place pneumatic piezometer data was presented which indicated that the drains constructed under the impoundment continue to function efficiently over time, and prevent water from seeping out the embankment toe by lowering the phreatic surface in the embankment. When Tailings Impoundment No. 1 is decommissioned, the head behind the embankment will decrease and further reduce the potential for seeps at the embankment toe. Reclamation of the cycloned sand embankment is discussed in Appendix D of the Annual Report submitted in March 1992. The reclamation consists of 2 feet of neutral rock or coarse borrow material for capping, followed by 2 feet of soil, then seeding. Reclamation of the cycloned sand face of Impoundment No. 1 was completed in 1996 and is described in the 1996 Annual Report.

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Sand from the Impoundment No. 1 embankment was deposited at 3H:1V or flatter as discussed above, and it is expected that sands on the Impoundment No. 2 embankment will be deposited at a similar angle. If not, slopes will be reduced to 3H:1V.

Stipulation No. 11: GSM must initiate the cycloned sand tailing reclamation test plot, discussed in the application, no later than when Impoundment No. 1 is filled to capacity, and must monitor and report the effectiveness of the reclamation in controlling the oxidation reaction.

Tailing impoundment test plots were designed and monitored by D. Dollhopf and the Montana State University Land Rehabilitation and Reclamation Department. These plots were heavily monitored to provide data on infiltration and effectiveness of reclamation in limiting seepage, and are fully described in Appendix J of the Annual Report submitted in March 1992. A final report describing the results of this test plot research is provided in Appendix 5.6-1 of GSM's 1995 Permit Application (GSM 1995b). The agencies have concluded that this test plot research has been adequate to evaluate the sand tailings reclamation.

The results of this test plot research concluded that the tailings reclamation cap designs used on the test plots were effective at minimizing infiltration of water into the tailings, and thus, would minimize the amount of seepage from the tailings that would result from direct precipitation. The tailings cap, however, does not exclude oxygen. Therefore, in time, the tailings will acidify, providing a potential for ARD seepage.

Stipulation No. 12: GSM must place 18 inches of low permeability (10^{-7} cm/sec/yr) soils, in two 9-inch compacted lifts, over the entire final tailing surface, carried to the crest of the embankment face. GSM may apply to the agencies for alternative surface reclamation if GSM can document that an alternative would reduce the seepage of acid water to an equivalent degree as the 18-inch soil layer.

On page 34 of the Annual Report submitted in June 1991, GSM indicated that a permeability of 10^{-7} cm/sec was not achievable with most materials. The agencies agreed to revise the permeability requirement for the clay cap to 10^{-6} cm/sec. GSM constructed test plots on the tailings surface in 1992 to evaluate alternative reclamation methods to the clay cap as described in Appendix M of the 1992 Annual Report. The test plots established on the tailings material of Impoundment No. 1 showed that alternate methods of capping were equal to or more effective than a clay cap barrier in terms of preventing acid water seepage and promoting revegetation potentials. See Stipulations No. 13 and No. 18 in this section for further discussion regarding the results of the test plots constructed at Impoundment No. 1. The need for clay capping was reassessed by the agencies in their review of GSM's 1995 Permit Application.

Stipulation No. 13: GSM must develop a final monitoring plan for Impoundment No. 1, in consultation with the agencies, which must be submitted with the 1991 Annual Report. The plan must be designed to quantify the amount and quality of seepage and effectiveness of reclamation in limiting seepage from the impoundment.

a. Parameters to be monitored include phreatic water level in the impoundment, seepage, water recharge and quality and other measures for evaluating the effectiveness of reclamation.

b. If monitoring reveals that seepage quantity and quality are substantially different from predictions, GSM must revise its treatment plans and areas, in consultation with the agencies.

GSM constructed reclamation plots on a portion of Impoundment No. 1 to monitor the amount and quality of seepage and the effectiveness of reclamation in limiting seepage. The reclamation test plot plans developed with the help of D. Dollhopf and the Montana State University Land Rehabilitation and Reclamation Department was described in Appendix M of the 1992 Annual Report. The construction included several plots using various capping materials. The monitoring plan measured water levels, seepage, and recharge with pore water samplers, neutron access tubes, and piezometers. Test plot monitoring began in the fall of 1992. A final summary report was given in Appendix 5.6-1 of GSM's 1995 Permit Application. The summary report concluded that the tailings reclamation cap designs used on the test plots were effective at minimizing infiltration of water into the tailings, and thus, would minimize the amount of seepage from the tailings that would result from direct precipitation. The tailings cap, however, does not exclude oxygen. Therefore, in time, the tailings will acidify, providing a potential for ARD seepage.

Flow rates and water quality below the tailings impoundments are routinely monitored in the pumpback wells to determine the amount and quality of seepage as described in GSM's Water Resources Report submitted annually to the agencies. As described in the reclamation plan in Appendix D of the Annual Report submitted in March 1992, Impoundment No. 1 monitoring wells will be monitored until applicable water quality standards are met as required by Stipulation No. 14. Impoundment No. 1 pumpback wells will discharge into Impoundment No. 2 during mine life, and into a permanent water treatment plant thereafter until applicable water quality standards are met (Stipulation No. 15). All treatment plans will be reviewed at the end of mine life, and a decision will be made whether the closure plans need to be modified and submitted to the agencies (Stipulation No. 24).

Stipulation No. 14: Monitoring the pumpback wells associated with Impoundment No. 1 and reclamation effectiveness in limiting seepage and control of the acidifying reaction must continue until water quality standards can be met in the applicable surface and groundwater systems.

GSM routinely monitors water quality from the pumpback systems, and a commitment to continue to monitor water quality in the pumpback systems until water quality standards can be met is contained in both the existing and proposed reclamation plans. Existing water quality data are provided in Appendix AR-96-4.3 of the 1996 Annual Report. Discharge rates from the South Pump Back (SPB) and East Flank Pump Back (EFPB) groundwater interception/pumpback systems also are routinely monitored to evaluate pumpback well operational performance. This monitoring system should continue to be an adequate means of assessing reclamation effectiveness in terms of limiting seepage and meeting water quality standards.

Stipulation No. 15: Pumpback wells for Impoundment No. 1 must operate and discharge into Impoundment No. 2 during mine life. After mine life they must be pumped to the treatment plant or other approved facility until water quality standards can be met in the applicable surface and groundwater systems.

Decommissioning of Impoundment No. 1 began when Impoundment No. 2 became available in 1994. In 1996, GSM directed all discharge from Impoundment No. 1 pumpback wells into Impoundment No. 2, unless discharge lines were temporarily under maintenance or repair. As of late 1996, GSM eliminated the backup line from the pumpback systems to Impoundment No. 1 such that pumpback water can no longer be discharged to Impoundment No. 1 under any circumstances. The existing and proposed reclamation plan incorporates plans to treat the pumpback well water after mine life prior to disposal until pumpback well water meets all appropriate water quality criteria for discharge.

Stipulation No. 16: GSM must submit within 180 days of permit issuance, detailed specifications, for agency review and approval, for the permanent design and construction of the diversion structure around the tailings impoundments. The diversion system must be designed to handle runoff from one half the Probable Maximum Precipitation Event (PMP) and must include:

- *Diversion channel specifications;*
- *Dam specifications, for the five drainages to be diverted to the east and west of the impoundments; and*
- *Specifications for inlet, outlet, and gradient control structures that are required for the drainage dam reservoirs and final discharge to the natural drainages.*

Diversions must be constructed in accordance with the approved design. Annual maintenance of the diversion structures must be performed. Cost figures must be gathered during the remainder of mine life and must be used to adjust the financing for permanent water treatment to include the long-term maintenance of diversion structures.

A final design development report entitled "Supplemental Design Services, East Tailing Disposal Facility" was completed by Sergent Hauskins and Beckwith (SHB) Geotechnical Consulting Engineers of Phoenix, Arizona. Portions of the report discuss the diversion system design around both tailings impoundments. This report was submitted to the agencies on June 12, 1991, along with three construction plans showing the layout, survey data, cross-sections, and details of the design for diversion structures around both impoundments. The response to MDEQ comment number 43 in the 1992 Annual Report detailed the approval and construction work completed to date on the diversion channels around the impoundments.

Plans for Tailings Impoundment No. 1 (West Diversion) were submitted in 1988, 1989, and 1990, and approved with the permit for Amendment 008. Some modifications were made to these plans, and after considerable consultation, the agencies approved construction September 1, 1995. Construction started in late 1995 and will continue into 1997-1998.

The agencies reviewed the plans for Tailings Impoundment No. 2 (East Diversion) in 1990, and it was constructed in 1991. The main portion of the channel has functioned well; however, portions of the western one-half required repair because of bottom heaving and slope steepening from the 1994 ground movement. Grade reestablishment, channel reconfiguration, and riprapping were completed in 1996 at a cost of $25,276. The outfall on the east end will require modification after two intense thunderstorm runoff events repositioned some of the riprap and scoured the channel. A redesign of the outfall was submitted to and approved by the agencies. The outfall will be reconstructed with a slightly flatter invert and a bedded riprap which will prevent washing of fines from beneath and around the larger rock.

In summary, the diversions around the tailings impoundments have been designed and constructed in accordance with approved designs and should be effective at handling the designed runoff event. Annual maintenance costs are being tracked to provide data to calculate the costs for long-term maintenance.

Stipulation No. 17: GSM must submit a final grading plan, which includes cell-sizing and berm specifications, in the 1991 Annual Report which will distribute runoff from the 100-year, 24-hour storm event across the reclaimed Impoundment No. 1 and 2 surfaces to minimize both erosion and the concentration of standing water.

GSM submitted this plan under the response to Stipulation No. 17 in Chapter VII of the Annual Report submitted in March 1992. The plan also was discussed in Appendix D of this same report. The agencies evaluated GSM's compliance with this stipulation in July of 1992 and concluded that the stipulation requirements had been fulfilled.

Stipulation No. 18: GSM must initiate a test plot on Tailings Impoundment No. 1 to test the effectiveness of the approved reclamation plan and alternative reclamation scenarios that may be more effective in limiting seepage from the impoundments.

GSM constructed a series of reclamation test plots on Impoundment No. 1 during 1992 with D. Dollhopf and the Montana State University Land Rehabilitation and Reclamation Department. The test plots were designed to evaluate the effectiveness of the approved reclamation plan, as well as alternative reclamation scenarios. The test plot design and monitoring plan were fully described in Appendix M of the 1992 Annual Report and incorporates a number of features requested by the agencies. A final monitoring summary report can be found in Appendix 5.6-1 of GSM's 1995 Permit Application.

The plots tested three earthen material systems for capping and revegetating impounded tailings. Monitoring occurred through the latter part of 1993 with testing that included a simulated 10-year storm (rainfall) event. Dollhopf et al. determined that all cover systems tested were similar relative to the parameters tested and that any cover system evaluated would be effective in terms of decommissioning the tailings impoundment. It also was noted that a coversoil/borrow material system may exhibit better long-term stability than the other systems tested, which included a clay cap barrier, and that a cover soil/borrow material system may be more practical and cost "feasible" to construct.

It should be noted that the depths of the capping systems tested by Dollhopf et al. were deeper than that proposed by GSM for use at the project site. Additional on-site analyses conducted by GSM concluded that the proposed 48-inch cover depth would be adequate based on anticipated rainfall events, capillary rise potential, and the potential for revegetation success in terms of plant rooting depth and soil chemistry.

Mitigation Measure S-6 in the EIS proposes a limited continuing monitoring program to assess, through time, any negative changes to the applied plant growth medium.

Stipulation No. 19: Water balance in the pit must be monitored quarterly and submitted to the agencies, with inflow measurements, in the annual reports.

GSM monitored pit highwall seeps and pit dewatering discharge on a monthly basis during 1996 to characterize the occurrence of water in the pit. The monitoring results are used to verify earlier water balance modeling estimates for purposes of pit water management.

Pit seeps were difficult to monitor in 1996 due to poor access and safety concerns. However, GSM attempted to collect data on a monthly basis throughout 1996 to help predict the future occurrence and quality of pit water. A map showing pit seep locations, and seep monitoring data are provided in Appendix AR-96-4.6 of the 1996 Annual Report. The pit dewatering system consists of several sumps and shallow dewatering wells that intercept water along the pit floor, and two deeper wells located on the north highwall. The average pit dewatering rate in 1996 was approximately 37 gpm, based on inflow records of feed water to the water treatment plant in the mill facility. Pit water monitoring and reporting is ongoing.

Stipulation No. 20: Bond to assure funds for the construction and permanent operation of a permanent water treatment facility must be submitted when the pit intersects the anticipated water table at the 5,350-foot elevation. The amount of bond must be based on actuarial projections of funds required, taking into account:

- ***(a) anticipated starting date of treatment,***
- ***(b) final treatment methods,***
- ***(c) projected amount of water to be treated, which will be presumed to be 75 gpm unless data is developed which shows, to the agreement of the agencies, that the amount is different, and***
- ***(d) the costs of operation, depreciation and maintenance. If, in subsequent years, data is developed which shows, to the agreement of the agencies and GSM, that the amount of water to be treated changes from the original determination, the projection and the bond will be adjusted accordingly.***

Bond submitted in accordance with this stipulation must be converted to a permanent fund, under the control of the state, at the end of active mine operations.

Treatment of initial dewatered tailing effluents from Impoundment No. 2 was accounted for in GSM's bond submitted in June 1990. A study outlining permanent water treatment plans and expected costs at GSM was included as Appendix O in the Annual Report submitted in March 1992. This document was modified at the agencies' request to include a 10 percent contractor profit and is included as an appendix in the Stand Alone Permit document submitted in March 1993. The study covers costs to treat perpetual drainage from both the pit and tailings impoundments should it occur. In addition, treatment for initial dewatered tailings effluents was added to the study because the same treatment plant will be used.

In June 1992, GSM submitted additional bonding totaling $2,483,000 to cover pit water treatment as requested by the agencies. As described in the response to Stipulation No. 25, GSM increased its bond by an additional $945,702 June 27, 1996, for increased pit inflows.

Stipulation No. 21: As final pit walls are developed, GSM must use tree plantings on

benches and talus slopes where safety, stability, and materials quality allow.

The pit continues to be active and is enlarging, and few walls can be reclaimed under current operating conditions. The commitment to plant trees on benches and talus slopes has been made in the existing and proposed reclamation plans, with conditions of safety, stability, and materials quality taken into consideration.

A reasonable revegetation success potential is assumed given the methods selected for growth medium preparation in the existing and proposed reclamation plans, including the application of an oxide cap, where necessary. It should be noted that the pit acreage to be reclaimed is limited by the availability of soil and oxide cap material of acceptable quality and quantity.

Stipulation No. 22: Water, if the volume is significant (based on final pit configuration), must be diverted around the pit perimeter in permanent diversion structures which are designed to handle 100-year, 24-hour precipitation events. The design for this diversion, or documentation of insignificant run-on, must be submitted in the 1991 Annual Report.

The system for diverting storm runoff around the pit perimeter was designed in conjunction with systems for diverting storm water off and around the dump tops (Stipulation No. 4) and for diverting storm water off the dump slopes (Stipulation No. 6). These were described under the response to Stipulation No. 22 in Chapter VII of the Annual Report submitted in March 1992. The diversion structures have been designed for and should be effective at handling 100-year, 24-hour precipitation events.

Stipulation No. 23: GSM must develop a plan, in consultation with the agencies, to identify the potential for vertical flows and fracture flows from the pit. This plan must be submitted with the 1991 Annual Report.

The plan to identify vertical and fracture flows from the pit was included with the Annual Report submitted in June 1991, in the response to Stipulation No. 9 in Chapter V. GSM has identified a potential for vertical and fracture flows from the pit. If fractures exist which provide a hydraulic connection to the colluvium, it will be necessary to maintain the pit groundwater levels at an elevation of 5,050 feet to maintain a hydrologic gradient for groundwater to flow towards the pit.

Mitigation Measure W-2 in the EIS was developed to address this issue and includes measures to prevent pit water elevation levels from exceeding 5,050 feet in elevation.

Stipulation No. 24: At the end of mine life, GSM must review the treatment plan and determine whether or not closure plans need to be modified based on data and other information accumulated during mine life. GSM's review and conclusions must be submitted to the agencies and GSM may apply for a revision. The agencies reserve the right to require a modification of the Permit under 82-4-337, MCA.

In the existing and proposed reclamation plans, GSM has committed to review the treatment plan at the end of mine life using water monitoring information from the pit, waste rock dumps, and tailing areas.

Stipulation No. 25: With each Annual Report, which must be submitted June 27 of each year, GSM must submit additional bond in the amount of $1,158,000, for the 12 years through and including 2002. In the years 2003 and

2001, $408,000 must be submitted, unless these amounts are revised by future bond evaluations and documented in writing.

In addition, the current format of the annual report must be expanded to include:

1. *reclamation data with summaries and analysis for all reclamation test plots;*
2. *as-builts required by Stipulation Nos. 3 and 4;*
3. *acid-base potential data from Stipulation No's. 5 and 6 for those years in which slope reduction and rock capping, respectively, have been implemented;*
4. *soil sampling data (Stipulation No. 7);*
5. *erosion data (Stipulation No. 8);*
6. *data and findings from monitoring of Impoundment No. 1 (Stipulation No. 13);*
7. *pumpback well data (Stipulation No. 14);*
8. *water balance data, inflows, and outflows for the pit (Stipulation Nos. 19 and 23);*
9. *soil and oxidized cap rock volumes, locations and materials balance; and*
10. *noxious weed control report.*

Data must continue to be submitted annually for as long as the related activity is underway.

GSM has been increasing its bond by $1,158,000 each year. GSM increased its reclamation bond by $1,158,000 in June 1997 to bring the total reclamation bond to $38,043,902. The total bond amount includes $948,650 of unobligated bond.

The format of the annual reports has been expanded to include each of the itemized sections above. In the existing and proposed reclamation plans, GSM has committed to continue to submit data to the agencies annually, for as long as the related reclamation activity is underway.

Stipulation No. 26: At the end of operations, GSM must test areas which have the potential to acidify and take any additional measures necessary to cover and revegetate these areas, or to channel drainage from these areas to treatment facilities, where necessary. Areas to be considered are portions of haul roads constructed through un-oxidized materials, areas around the facilities where spillage of un-oxidized rock occurred, and where tailing slurry line spillage have occurred.

In the existing and proposed reclamation plans GSM has committed to test areas which have potential to acidify at the end of mine life and take additional measures necessary to cover, revegetate, and channel drainage from these areas. GSM has committed to this for all facility areas, including but not limited to the plant site/buildings area, road and utility corridors.

Stipulation No. 27: All studies identified in the stipulations above, must clearly define the study objectives, define deliverables, and identify dates by which the deliverables must be submitted.

GSM must meet annually with the DSL, the BLM, and the WQB, to discuss monitoring and research findings and to determine the need for additional modifications of reclamation.

GSM meets annually with MDEQ and BLM to discuss existing study objectives, deliverables, monitoring and research findings, and to determine the need for additional modifications to the reclamation plan.

Stipulation No. 28: GSM must submit a final plan which identifies objectives, deliverables *and due dates for all reclamation test plots with the 1991 Annual Report. The plan must be developed in consultation with the agencies.*

A plan was described under the response to Stipulation No. 28 in Chapter VII of the Annual Report submitted in March 1992. The description provided was reviewed by the agencies and deemed adequate.

Stipulation No. 29: GSM must submit a revised, consolidated operating and reclamation plan which reflects all of the documents identified in the first paragraph of this amendment, discussed in the May 30, 1990, EA, and related information, as well as the designs and plans required in the stipulations above, with the 1991 Annual Report.

The single-volume operating and reclamation plan submitted in 1993 now serves as an up to date summary of GSM's current operating and reclamation plan. It is updated as needed.

Stipulation No. 30: Wherever in the stipulations GSM is required to develop a study, plan, specification design or other document, that study, plan, design, specification or other document must be submitted to the Department, with copies to the BLM, for approval. Wherever approval is required, this approval requirement means that

(1) If approval is not granted, the study, plan, design, specification or other document or documentation may not be implemented and no action may be undertaken pursuant to the study, plan, design, specification or other document or documentation, and

(2) If approval is granted, GSM must conduct its operations in accordance with the study, plan, design, specification, or other document or documentation.

GSM has submitted the above-mentioned studies, plans, designs, specifications, or other documents to the agencies for approval. The single-volume operating and reclamation plan submitted in 1993 contains the current, agency-approved studies, plans, specification designs, and other documentation.

Stipulation No. 31: Prior to further disturbance, GSM must complete a level III cultural resource survey on the north half of Section 29, T2N, R3W. The survey report must be filed with the agencies no later than the 1991 Annual Report and GSM must implement the mitigation measures necessary to assure compliance with the National Historic Preservation Act, as amended.

A level III cultural resource survey was completed for T2N, R3W, Section 29, N½ by Western Cultural Resource Management, Inc. The report entitled *A Cultural Resource Inventory For A Proposed Exploratory Drill Hole Program For The Golden Sunlight Mine In Jefferson County, Montana* was submitted to DSL in November 1990. The inventory resulted in the recording of seven new sites (24JF937 to-942, -944), including two historic trash scatters and/or structures, two groups of prospect pits, an adit, and two rock cairns. An isolated find (24JF943) also was recorded. All of the sites, except 24JF711, -942, and -944 were determined ineligible to the NRHP with SHPO concurrence. Sites 24JF942 and -944 were considered eligible pending further evaluation (Warhank 1995; Huppe 1994). Site 24JF711 has been determined ineligible to the NRHP with SHPO concurrence (Wilmoth 1997).

ADDITIONAL ISSUES, MITIGATION MEASURES, AND IMPACT CONCLUSIONS

Numerous issues were identified during scoping and the environmental analysis completed for this EIS. These issues, along with appropriate mitigation measures and impact conclusions, are presented below by resource discipline. These issues apply to the Proposed Action and other alternatives. A summary comparison of impacts among alternatives is presented in summary tables (II-23 and II-24) at the end of Chapter II.

Geology, Minerals, and Paleontology

***Issue:** Future slide block movement.*

Mitigation Measure G-1 provides for continued geodetic monitoring programs to detect ground movements associated with the landslide blocks at Golden Sunlight Mine, in addition to monitoring of inclinometers and piezometers. Agency notification and review of block stability would occur if any one of several criteria are exceeded. Protocols have been developed for actions to be taken if renewed ground movement is detected. This measure would provide for detection of any further ground movements in the identified slide block areas. If movement is detected, appropriate mitigation measures could be taken to re-establish stability, such as redistribution of waste rock, dewatering, recontouring, and buttress construction in slide areas.

***Issue:** Potential ground movements in the East Waste Rock Dump.*

Mitigation Measure G-2 provides for implementation of a geodetic monitoring program to detect ground movements associated with the East Waste Rock Dump area, similar to the existing program at the mine, and the measures described in Mitigation Measure G-1. If any ground movements are detected, the appropriate agencies would be notified promptly, and monitoring intervals and reporting frequencies increased as appropriate. Protocols would be developed for actions to be taken if ground movement is detected. This measure would provide for detection of any ground movements in the East Waste Rock Dump and the implementation of appropriate mitigation measures to re-establish stability.

***Issue:** Movement of structural foundations.*

Early warning of plant site movement is being provided by Sunlight Block monitoring, as described in Mitigation Measure G-1. A stability monitoring program for the ore processing facilities also has been initiated, with specific measures to supplement the primary (Sunlight Block) movement monitoring. Mitigation Measure G-3 provides for the continuation of these monitoring programs. If adverse movement is detected, the appropriate agencies would be promptly notified, and steps taken to ensure the safety of employees and protection of the environment. This measure would provide for detection of any movements within the ore processing facilities area. If movement is detected, appropriate mitigation measures could be taken to re-establish stability, such as draining of processing fluids to the tailings impoundments, and structural refitting of facilities to accommodate movements.

***Issue:** Damage to tailings impoundment caps due to consolidation settlement.*

Settlements in the tailings impoundments, which are expected over time as consolidation occurs, could result in differential settlements of the impoundment reclamation caps. This, in turn, could result in ponding of surface water or disturbance of the cover in such a way as to reduce the cover effectiveness in preventing infiltration. Mitigation Measure G-4 provides for maintenance activities, including regrading of the impoundment surface in affected areas, and repair of the cover as needed to restore its function and maintain the desired slopes on the impoundment surface. This would be effective in maintaining cover integrity and function.

Issue: Construction feasibility concerns regarding pit backfilling activities under the Partial Backfill Alternative.

This issue applies only to the Partial Backfill Alternative. Worker safety and consistent cover of pit wall surfaces are concerns for the proposed placement of backfill in the pit. Mitigation Measure G-5 provides for an evaluation of potential alternative construction methods. These include backfilling by working up from the bottom of the pit, rather than end dumping, to create a more consistent fill and reduce the risks to workers. However, greater volumes of backfill material would be required, and the method may be cost-prohibitive. Another method to consider is the use of remote-controlled equipment for grading of the pit wall cover slopes, to minimize safety risks to workers. Alternative construction methods would likely entail considerable additional costs, and would not contribute to a reliable long-term reclamation plan.

Issue: Direct impacts to previously unidentified paleontological resources.

With implementation of Mitigation Measure P-1, if previously undocumented paleontological deposits are located during project operations, GSM would cease activities in the area until the resources could be examined by professional paleontologists approved by the state and/or BLM. If significant paleontological resources are identified, impacts would be mitigated through an appropriate treatment plan approved by the state and/or the BLM, or through site avoidance. This measure would allow for the evaluation of previously unknown and potentially significant paleontological deposits that may be discovered during mining activities and would provide adequate time for presentation and recovery of the resources if this is deemed necessary by the state or BLM.

Water Resources

Issue: Identification and replacement of reduced discharge or reduced water quality at springs and seeps.

Mitigation Measure W-1 provides for establishing a monitoring program to quantify discharge and water quality at springs in the project area, and to identify any reductions in flow or water quality, with data collection events frequent enough to detect spring response to seasonal variations and pit dewatering. Mitigation of reduced discharge at springs would be accomplished by further development of the affected spring or by diverting water from the permanent water treatment plant to provide water for wildlife and livestock use. Mitigation of reduced water quality would be accomplished by establishing additional water sources for wildlife and livestock use, using treated water discharged from the permanent water treatment plant. This measure would document variations in spring discharge and water quality and provide data to determine if changes in spring flows or water quality are occurring as the result of mining activities. In addition, the measure would provide continued surface water sources at the mine site, greatly reducing impacts to wildlife and livestock.

Issue: Pit groundwater discharge to adjacent hydrostratigraphic units

Mitigation Measure W-2 would provide for monitoring of pit pond water levels to ensure that the pit pond elevation remains below the groundwater discharge threshold elevation of 5,050 feet. If the level exceeds this elevation, appropriate measures would be taken to reduce the pond level, including additional pumping and/or water treatment facilities. In addition, water level and quality monitoring downgradient of the pit would verify whether a maximum pond elevation of 5,050 feet is effective, or whether adjustments are needed in the proposed maximum pond elevation in order to protect groundwater outside the pit. This measure would prevent pit pond water levels from exceeding the threshold elevation, and, therefore, mitigate the potential for degradation of the surrounding groundwater.

Issue: Erosion from increased flows in stream channels due to the Sheep Rock or return diversion.

Under the Proposed Action, increased erosion could occur within Conrow Creek and the tributary to Conrow Creek, following the introduction of additional flows from Sheep Rock Creek. Under the Return Diversion Alternative, increased erosion could occur within the unnamed tributary to Sheep Rock Creek as a result of diverted flows. Mitigation Measure W-3 provides for periodic examination and maintenance of the channels, including the addition of erosion protection in affected channel reaches, and/or installation of check dams or other grade control structures. GSM has committed to visually inspecting Conrow Creek after storm events and addressing channel damage. This would apply for the unnamed tributary to Sheep Rock Creek under the Return Diversion Alternative. These measures would mitigate erosion from increased flows in affected stream channels.

Issue: ARD release from dumps that is either premature because of transport along preferential, discrete flow paths, and/or of greater flow rate than modeled performance because of higher than expected infiltration.

Mitigation Measure W-4 provides for the implementation of several measures if the data from existing monitoring wells and/or spring flows indicate that changes in water quality are occurring which are likely to exceed applicable regulatory requirements. These include:

a) If water quality impacts are detected in monitoring wells at the mixing zone boundary downgradient from the East Waste Rock Dump, a groundwater capture system similar to the system described in Appendix A for the West Waste Rock Dump would be installed. Capture of discrete plumes from the East Waste Rock Dump (from transport along preferential flow paths) would not require a well system as extensive as assumed for the West Waste Rock Dump;

b) ARD-impacted seeps may emerge at the toes of the dumps where preferential drainage paths occur within the dumps that lead to discrete "perched" saturated zones at their base. Shallow groundwater capture systems such as toe drains around the peripheries of the waste rock dumps would be installed to supplement the primary, deep capture well system; or

c) *In situ* treatment systems would be installed in the shallow ("perched") aquifer zones, including the alluvial materials over bedrock on the west side, and/or the colluvial/alluvial materials in Rattlesnake Gulch or at other locations downgradient of the East Waste Rock Dump.

These supplemental groundwater capture systems would allow interception of contaminated groundwater that bypasses the primary capture well system, and capture of these potential ARD sources before the contaminated water migrates downgradient to beneficial uses, or to sensitive receptors, such as the Jefferson River.

***Issue:** Impacts to beneficial uses of water downgradient of capture system because of capture drawdown effects.*

Mitigation Measure W-5 provides for discharging treated water from the permanent water treatment plant back to the aquifer as recharge, or discharging as surface water in order to minimize impacts to downgradient beneficial uses. This measure would minimize impacts to beneficial uses of water downgradient of the groundwater capture system.

***Issue:** Total of combined inflows to water treatment plant exceed the capacity of the plant.*

Mitigation Measure W-6 provides for reevaluating the capacity of the permanent water treatment plant and incorporating results into the final design within two years prior to mine closure. At that time, the actual rate and quality of pit inflow during peak flow and low flow periods, and the total rate and quality of groundwater captured in the tailing area will be better known. Based on the degree of uncertainty of the rate of inflow from future sources, a contingency measure of up to 25 percent additional flow would be incorporated into the treatment plant capacity, and a contingency to provide storage for up to 6 months of anticipated water inflow would be included. This would provide for time to modify the plant if needed for unanticipated future inflows. Alternatively, a new, additional water treatment facility would be constructed to address treatment of a specific source or sources, to be built at the time such sources are identified. Sufficient additional water treatment capacity, whether added to the permanent water treatment plant design or as an additional separate facility, would provide for treatment of unanticipated inflows.

***Issue:** Cracking of tailings impoundment covers due to desiccation and/or freeze-thaw effects.*

This issue applies only to the No Action Alternative, which requires an 18-inch clay layer in the tailings impoundment covers. Mitigation Measure W-7 provides for replacing the 18-inch clay layer of the cover for Tailings Impoundment No. 1 with an additional 18 inches [illegible] agency-approved alluvial borrow [illegible] The additional 18-inch layer of alluvial [illegible] material is not needed for the lined Tailings Impoundment No. 2. Field studies indicate that this will enhance the cover system over the unlined Tailings Impoundment No. 1 and help to minimize the seepage that needs to be collected and pumped back for treatment. All other alternatives, except the No Action, utilize the cover described in this mitigation measure.

***Issue:** Leakage from HDPE liner system underlying Tailings Impoundment No. 2 and reclaim ponds.*

Mitigation Measure W-8 provides that if the data from existing monitoring wells indicate that the Tailings Impoundment No. 2 and/or reclaim ponds liners are leaking, pumpback wells would be installed as needed to effectively contain any impoundment fluid plumes. The additional pumpback flows would have to be treated in an enlarged or supplemental water treatment facility, as described under Mitigation Measure W-6. Groundwater interception and pumpback have been shown to be effective for controlling seepage from Tailings Impoundment No. 1, and would likely also be effective for containing leaks from Tailings Impoundment No. 2 and/or the reclaim ponds.

Issue: Preventing contact between natural groundwater and tailings material in Tailings Impoundment No. 1 in order to reduce or eliminate the mobilization of cyanide, TDS, and ARD constituents.

Mitigation Measure W-9 provides for constructing a trench-drain upgradient of Tailings Impoundment No. 1 prior to mine closure, in order to intercept groundwater associated with an historic spring at the north end of the unlined impoundment and route the water by gravity drainage to a percolation pond away from the impoundment area. This measure would lower the groundwater table downgradient of the drain and beneath the former spring area such that the hydraulic contact between groundwater and tailings is eliminated. The success of this system would be monitored for a sufficient amount of time prior to mine closure so that the results could be incorporated into the final design of the water treatment plant. Alternatively, one or more dewatering wells could be constructed through the tailings impoundment in the former spring area. This measure would reduce the amount of cyanide, TDS, and ARD constituents that could be mobilized in groundwater beneath the impoundment.

Issue: Identification of bedrock fractures to optimize efficiency of the west side groundwater capture system.

Mitigation Measure W-10 provides for conducting a hydrogeologic investigation of the bedrock hydrostratigraphic unit on the west side of the project area in order to identify major water-bearing fractures for purposes of monitoring and future groundwater capture of dump seepage. The results of the study would be used to determine optimum groundwater monitoring locations and to design a groundwater capture system to prevent impacts to beneficial water uses. These measures would increase the efficiency of the proposed groundwater capture system.

Issue: Damage to the permanent diversion of Sheep Rock Creek at less than the design flows (one-half PMF), exposing waste rock to surface water flows.

Mitigation Measure W-11 provides for scheduled operational inspections to monitor any damage which occurs to the permanent diversion channels during flow events less than the designated design flow criteria. Any such damage would be repaired as part of scheduled operational maintenance activities. These measures would allow timely repair of any damage to channels which could compromise their intended performance.

Soils and Reclamation

Issue: Monitoring and testing of soils affected by steam venting at the waste rock dump test plots and tracking number and size of vents on all reclaimed surfaces over acid-producing materials.

Mitigation Measure S-1 provides for implementing a program for the continued monitoring of existing waste rock test plots to further assess the impacts, if any, that steam venting may have on reapplied soil or establishing vegetation. The program would consist of agency reclamation specialists annually monitoring the number, location, and size of steam vents and the extent of modified plant communities surrounding vent locations. If detrimental effects to establishing vegetation communities are observed on more than 0.1 percent of the total reclaimed area covering acid-producing materials, GSM would be required to rock armor vent locations, conduct sampling and testing of soils, and prepare a plan for reducing impacts. Soil parameters to be tested would include, at a minimum, soil pH and ABA. The cost for the program should be included in a post-mine maintenance bond. This measure would be an effective means of assessing and mitigating the changes occurring as a result of steam venting.

***Issue:* Salvaging or providing a sufficient volume of oxide rock, soil, or borrow material for capping needs under the No Action Alternative.**

Under Mitigation Measure S-2, GSM would include in its bond calculations the provision for salvaging a sufficient volume of oxide rock, soil, or borrow material to make up for the projected shortfalls of suitable capping material under the No Action Alternative. This would provide for sufficient capping needs and would promote reclamation success.

***Issue:* Salvaging a sufficient volume of soil (or borrow material) for reclamation under the No Action Alternative and Divided Dump Alternative (minimum disturbance scenario).**

Mitigation Measure S-3 requires that the agency engineer identify which soil stockpiles and which areas to be resoiled would be affected by the projected soil or borrow material shortfall. A salvage area would then be identified and a bond calculation made to recover the needed volume of soil or borrow material at the time of reclamation. This measure would provide for sufficient bond funds to address the soil volume shortfalls and would promote reclamation success.

***Issue:* Providing for application of soils containing high (up to 50 percent by volume) rock fragment contents on 2:1 and 3:1 waste rock dump slopes as a part of the reclamation cap proposed for waste rock dumps.**

Mitigation Measure S-4 provides that, based on the results of on-site studies, GSM use soils containing high (up to 50 percent by volume) rock fragment contents as part of the reclamation cap proposed for waste rock dumps. A combination of alternate erosion control techniques may be used in lieu of the proven high rock fragment content soils, if it can be shown that the substituted technique(s) will provide the same effect with regard to reducing erosion potentials on reclaimed slopes. This measure should be highly effective in reducing erosion potentials for reclaimed areas, particularly steep slopes.

***Issue:* Providing for mulch or a "mulch effect" as a part of the revegetation sequence proposed for disturbed areas during the reclamation phase of this project.**

Mitigation Measure S-5 provides that, based on the results of on-site test plot studies, GSM include mulching as part of the revegetation technique sequence proposed for disturbed areas at the project site. A combination of alternate mulching, cover crop, or seedbed manipulation techniques may be used in lieu of the proven mulching technique, if it can be shown that the substituted technique(s) will provide the same effect with regard to reducing erosion potentials and increasing revegetation success. This measure should be highly effective in increasing revegetation success potential for disturbed areas, particularly steep slopes.

Issue: Long-term success of waste rock and tailings revegetation using oxide waste rock and borrow material capping.

Mitigation Measure S-6 provides for the continuing evaluation of existing waste rock test plots (initiated by Schafer and Associates) to assess the effectiveness of waste rock capping techniques developed on-site. Several specific parameters should be assessed in order to determine if detrimental changes are occurring within the root zone through time. Plant cover and species composition assessments should continue, and estimates of erosion also should be included. A similar but abbreviated monitoring effort should be conducted at the tailings facility and selected waste rock dump sites to assess the potential for capillary rise from the tailings into the reapplied soil materials and acidification of reapplied soil over waste rock, respectively. The length of time for monitoring should be determined by GSM, MDEQ, and the BLM. This measure would be a highly effective means of assessing the changes, if any, in seedbed materials through time as a result of the chemical characteristics of the material over which the soils were applied.

Vegetation and Wetlands

No mitigation measures are proposed for vegetation. See Appendix N for a detailed description of wetland mitigation measures.

Wildlife and Fisheries Resources

Issue: Potential bat and avian contact with poor quality pit water.

Mitigation Measure WF-1 requires that, when the pit lake forms, a monitoring program is implemented to determine whether wildlife species are utilizing the pit lake for foraging or other activities. If this occurs, a hazing program similar to that used for the tailings impoundments would be developed and implemented. This measure would minimize the impacts to bat and avian species from contact with poor quality pit water.

Issue: Loss of potential bat habitat.

Mitigation Measure WF-2 requires conducting an inspection or survey of existing mine shafts and adits prior to initiation of mining activities in order to determine bat occupancy. GSM would notify the BLM prior to closing any shafts, adits, or man-made structures on BLM-managed land during mine operation. BLM would determine whether additional protection measures are necessary to prevent impacts to bat species that may inhabit these areas. These measures would prevent any direct impacts to bat species that may occupy abandoned underground openings. Long-term, indirect impacts would still occur.

Issue: Loss of raptor nesting habitat.

Under Mitigation Measure WF-3, raptor surveys would be conducted during the breeding season prior to the initiation of mining activities on previously undisturbed lands between March 1 and August 15. If an occupied breeding territory or active nest site is located, restrictions would be applied to all disturbance activities during the breeding season. Measures would be identified by the agencies to protect breeding raptors, possibly including construction constraints within 0.5 mile of nests during the sensitive early periods of the breeding season (e.g., courtship and incubation). The historic raptor nest located north of the tailings impoundment should be avoided. If it cannot be avoided, this nest should be removed outside the active breeding season (March 1 to August 15). These measures would prevent disturbance of, and minimize the loss of annual productivity for breeding raptors.

Issue: Loss of migratory bird nesting habitat.

Under Mitigation Measure WF-4, removal of native vegetation on previously undisturbed lands would be prohibited between May 1 and July 31 to protect actively nesting migratory birds. Alternatively, breeding bird surveys approved by the agencies could be conducted during the breeding season and prior to site disturbance to identify whether occupied territories or active migratory bird nest sites could occur within the areas to be disturbed. If nesting migratory birds are not located during the survey, construction could proceed. If nesting migratory birds are found, GSM would coordinate with the agencies and based on the bird species detected, the agency biologist would make recommendations on whether appropriate protection measures should be implemented (e.g., avoidance). These measures would be effective in minimizing the direct loss of migratory birds and identifying any sensitive breeding areas prior to site disturbances.

Threatened, Endangered, and Candidate Species

Mitigation Measures WF-1 and WF-2 discussed in the Wildlife and Fisheries Resources section above also apply to this resource. No additional mitigation measures are proposed.

Air Quality

No mitigation measures are proposed for this resource.

Land Uses and Plans

No mitigation measures are proposed for this resource.

Aesthetic Resources

No mitigation measures are proposed for this resource.

Social and Economic Resources

No mitigation measures are proposed for this resource.

Hazardous Materials and Wastes

Issue: Generation of unnecessary hazardous waste due to spills of hazardous materials onto soils.

Under Mitigation Measure HM-1, all hazardous materials would be stored in a berm lined with an impermeable layer, rather than a soil or gravel berm. Spills within the containment berm could then be recovered with a vacuum truck and either recycled or disposed of as necessary. This measure would reduce the impacts due to spills around tanks and storage vessels.

Issue: Generation of unnecessary hazardous waste due to drainage from routine maintenance operations.

Under Mitigation Measure HM-2, the impacts to soil from the drainage of areas such as equipment/truck wash stations and equipment maintenance facilities would be mitigated by collecting and draining all washout/runoff from the area into an oil/water separator before discharge to surface waters. Paving these areas such that washout/runoff collected in a central drain also would eliminate the impact to soil. Used oil sludge could then be recovered with a vacuum truck and either recycled or disposed of as necessary. This measure would reduce the impacts from the uncontrolled runoff of equipment wash rinsate.

Issue: Generation of unnecessary hazardous waste due to improper handling and/or response to hazardous material spills.

Under Mitigation Measure HM-3, the impacts from a minor spill of hazardous material would be mitigated by training all personnel in the proper reporting and response requirements. Rapid and appropriate response to minor releases of hazardous material would reduce the amount of soil and/or water that would be impacted. Requiring all personnel to have OSHA hazardous material training would reduce the chance of accidents in storage and transport of hazardous materials and increase overall safety.

Cultural Resources

Issue: Direct impacts to known cultural resources.

Mitigation Measure C-1 provides for conducting data recovery at NRHP sites eligible under criteria "d" directly impacted by mining activities, to be carried out in accordance with a formal treatment plan prepared by a professional archaeologist and approved by the BLM, the MDEQ, the SHPO, and the ACHP prior to project commencement. Mitigation for directly affected sites eligible to the NRHP under criteria a, b, and c also would be addressed in a treatment plan, and would include such measures as information kiosks and artifact displays. This measure would mitigate adverse effects from direct impacts through data recovery, collection of available site information, and educational measures as determined on a site by site basis, and would meet legal requirements under 36 CFR 800.

Issue: Indirect impacts to cultural resources from mining activities.

Mitigation Measure C-2 would provide for limiting access to archaeological sites on private land, education of GSM employees as to the fragile nature of cultural resources, and a strict GSM management policy regarding casual collecting of artifacts from project lands. This measure would reduce, but not eliminate, indirect impacts to cultural resources on both public and private lands.

Issue: Surveying of project areas previously uninventoried.

Under Mitigation Measure C-3, Class III surveys would be conducted by qualified archaeologists in those areas of Section 36 that have not been previously inventoried if disturbance in those areas is planned (applicable to the Divided Dump Alternative). Surveys would occur before disturbance and before issuance of the ROD. Any potential effects to sites identified in these areas would be considered through the Section 106 process. This measure would identify and assist in mitigating adverse effects to currently unidentified sites that may occur in the unsurveyed areas.

Native American Concerns

Issue: Consultation on previously unidentified sites of potential significance to Native Americans.

Mitigation Measure NA-1 provides for consultation with local tribal representatives if Class III field surveys in Section 36 (see

Measure C-3) identify sites of potential concern to Native Americans. Consultation would be conducted to determine if the sites should be considered important traditional cultural properties, and if so, to further determine the appropriate mitigation measures to avoid adverse impacts. The measure would assist in identifying and mitigating adverse effects to currently unidentified sites that may be of significance to Native Americans.

AGENCY-PREFERRED ALTERNATIVE

The rules and regulations implementing MEPA and NEPA (A.R.M. 17.4.617 and 40 CFR 1502.14, respectively) require that the agencies indicate a preferred alternative, if one has been identified. Stating a preference at this time is not a final decision. The preferred alternative could change in response to public comment on the Draft EIS, new information that becomes available, or new analysis that might be needed in preparing the Final EIS. The preferred alternative at this time is the Proposed Action as modified by the Return Diversion and No Pit Pond alternatives.

Rationale for Selection

- The Proposed Action best achieves Golden Sunlight's goals for developing its gold reserves. Waste rock dumps reclaimed at the proposed combination of 3:1 and 2:1 slopes are expected to be stable. The oxide rock and soil cap on the dumps provides an adequate medium for revegetation and should minimize soil erosion and water infiltration.
- The Return Diversion alternative, as it modifies the Proposed Action, avoids potential erosion and channel damage problems associated with the proposed diversion of upper Sheep Rock Creek into the tributary of Conrow Creek. The Return Diversion alternative avoids placement of acid-generating waste rock in adjacent drainages, as could occur under the Divided Dump alternative, thus concentrating in a smaller area the anticipated impacts to groundwater associated with ARD seepage from the dumps.
- The No Pit Pond alternative further modifies the Proposed Action to better handle the problem of objectionable effluents from the mine by eliminating the lake of poor quality water that would have formed in the pit after mine closure. This in turn eliminates a potential significant impact to wildlife that might have otherwise come in contact with the pit water.

Select Mitigation Measures

If this alternative is implemented, the following mitigation measures would likely be applied.

- ARD seepage from the existing waste rock dumps as well as from proposed dump expansions is expected in the future. The minimum practicable groundwater mixing zone would be determined and granted. In order to achieve the minimum size for the mixing zone, additional geotechnical and geohydrological characterization of the hydrostratigraphic units downgradient of the waste rock dumps would be performed for both the west and east waste rock dump complexes. This measure would improve the precision of placement and the effectiveness of monitoring and capture wells within the mixing zone by delineating fracture systems and other preferential flowpaths that could allow ARD to move more easily and with less likelihood of being naturally buffered. The mixing zone boundaries would be further refined in accordance with the new information obtained.

To reduce the amount of ARD seepage reaching the groundwater, drains would be installed below the edges of existing dumps before final contouring and reclamation. Engineered limestone drains would be placed in Sheep Rock Creek and other ephemeral drainages to collect, channel, and partially treat seepage from expanded waste rock dumps on the east side. Collected water would be treated in the water treatment plant.

- Water quality and quantity at existing springs would be monitored. If springs deteriorated, replacement water would be supplied from the water treatment plant, or new sources would be developed. Decreases in water for such beneficial uses as wildlife and livestock watering, due to groundwater drawdown from capture wells and pit pumping, would be compensated for by providing water from the water treatment plant.

  The design for the return diversion would be refined to improve stability and efficiency and reduce maintenance requirements. Refinements could include: sizing to carry extreme runoff; excavating into bedrock to improve stability; building to gradients that more closely approach the gradients of the existing channel to improve the diversion's function as a stormwater drain and reduce sediment buildup and down cutting, and; lining or grouting to reduce infiltration and improve stability.

In tentatively selecting the preferred alternative and these mitigation measures, the agencies have focused on their major legal requirements under such laws as the Metal Mine Reclamation Act, the Water Quality Act, and the Clean Water Act and the issues that pertain to these requirements. Other issues and possible mitigation measures remain under consideration and will be addressed, following the public comment period, in the Record of Decision after the Final EIS is published.

Pit Reclamation Feasibility

The Partial Backfill Alternative was analyzed in compliance with the Court Order of September 1, 1994 to evaluate the feasibility of pit reclamation, and pursuant to subsequent amendments to the Metal Mine Reclamation Act [at 82-4-336(7), MCA]. Partial backfilling is technically feasible as a method of pit reclamation.

With regard to economic feasibility, GSM provided MDEQ with engineer's cost estimates to accomplish the partial backfilling and reclamation of the pit as described in Chapter II of this Draft EIS. A staff engineer for MDEQ found the cost estimates to be reasonable.

MDEQ contracted an independent certified public accountant to review proprietary economic information provided by GSM containing income and cash flow projections based on the mine's historical costs, a range of gold prices, and the assumption that mining would continue as proposed and that the pit would subsequently be backfilled. MDEQ determined that a positive return on investment in the mine would be the initial threshold for determining the economic feasibility of backfilling. If partial backfilling would eliminate any reasonable likelihood of realizing a positive return on investment, backfilling would be considered uneconomic.

The certified public accountant found GSM's economic information to be reasonable and found nothing to suggest that the underlying assumptions were not reasonable. The projections indicate that a positive rate of return for continued mining under the Proposed Action would be realized only if the price of gold was sustained at $400 per ounce during the analysis period of 1997 through 2003. The return on investment would be very small for the period.

Fluctuations in gold prices will affect the results of the Proposed Action more than any other single factor. Current market indications suggest that the price of gold will average around $350 per ounce through the period with little to suggest an upturn in the near future.

A sustained gold price of $350 per ounce for the period would result in a net loss under the Proposed Action, though with a positive cash flow. This is typical of a mining operation which requires a large initial investment that is recovered over the life of the mine. With gold at $350 per ounce and the requirement to partially backfill, GSM would not be able to recoup its initial investment at a profit.

Based on the analysis summarized above, it does not appear that there would be any reasonable likelihood of GSM realizing a positive return on investment. Therefore, it has been determined that partial backfilling is not an economically feasible method of pit reclamation. Consequently, the agencies' preferred alternative does not include partial backfilling.

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CHAPTER 1

Introduction

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I INTRODUCTION

Golden Sunlight Mines, Inc. (GSM) mines and processes gold-bearing ore on public and private lands approximately 5 miles northeast of Whitehall, Montana (Map I-1). Existing mining operations are located in Sections 19, 20, 28, 29, 30, 32, and 33; Township 2 North (T2N); Range 3 West (R3W); Section 6, T1N, R3W; and Sections 24 and 25, T2N, R4W (Map I-2).

This Environmental Impact Statement (EIS) addresses a 1994 Montana District Court decision requiring that an EIS be prepared to evaluate the environmental effects of implementing an amendment to GSM's Operating Permit (Amendment 008 to Operating Permit No. 00065). This EIS also addresses additional proposed changes in GSM's mining operations that would provide for continued mining at the existing mine site through 2005.

On September 1, 1994, the District Court ruled that the Montana Department of State Lands (MDSL) improperly evaluated the potential for significant environmental impacts that could result from implementation of Amendment 008 to Operating Permit No. 00065. The District Court ruled that an EIS must be prepared to further evaluate these impacts. On July 1, 1995, MDSL was reorganized by legislative action and its mine land reclamation regulatory functions were assumed by the newly created Montana Department of Environmental Quality (MDEQ). The new MDEQ assumed MDSL's responsibility for preparing an EIS for Amendment 008.

The District Court decision required that MDEQ further evaluate the specific Mitigation Measures and reclamation plan proposed for Amendment 008. This EIS evaluates these Mitigation Measures and the reclamation plan as they apply to the existing mining operations. This EIS also evaluates a 1995 proposal by GSM to amend its state and federal Operating Permit to provide for continued mining (Hard Rock Mining Permit Application for an Amendment to Operating Permit No. 00065, August 1995). No significant changes in ore processing, equipment, or employment levels would result from continued mining. However, continued mining would expand the disturbances from open pit mining and waste rock disposal, and require that larger areas be reclaimed. The MDEQ and United States Department of the Interior, Bureau of Land Management (BLM) have determined that this EIS should thoroughly investigate the environmental impacts associated with the issues raised by the 1994 District Court decision, as well as the environmental impacts associated with continued mining.

I.A RELEVANT HISTORY OF THE GOLDEN SUNLIGHT MINE

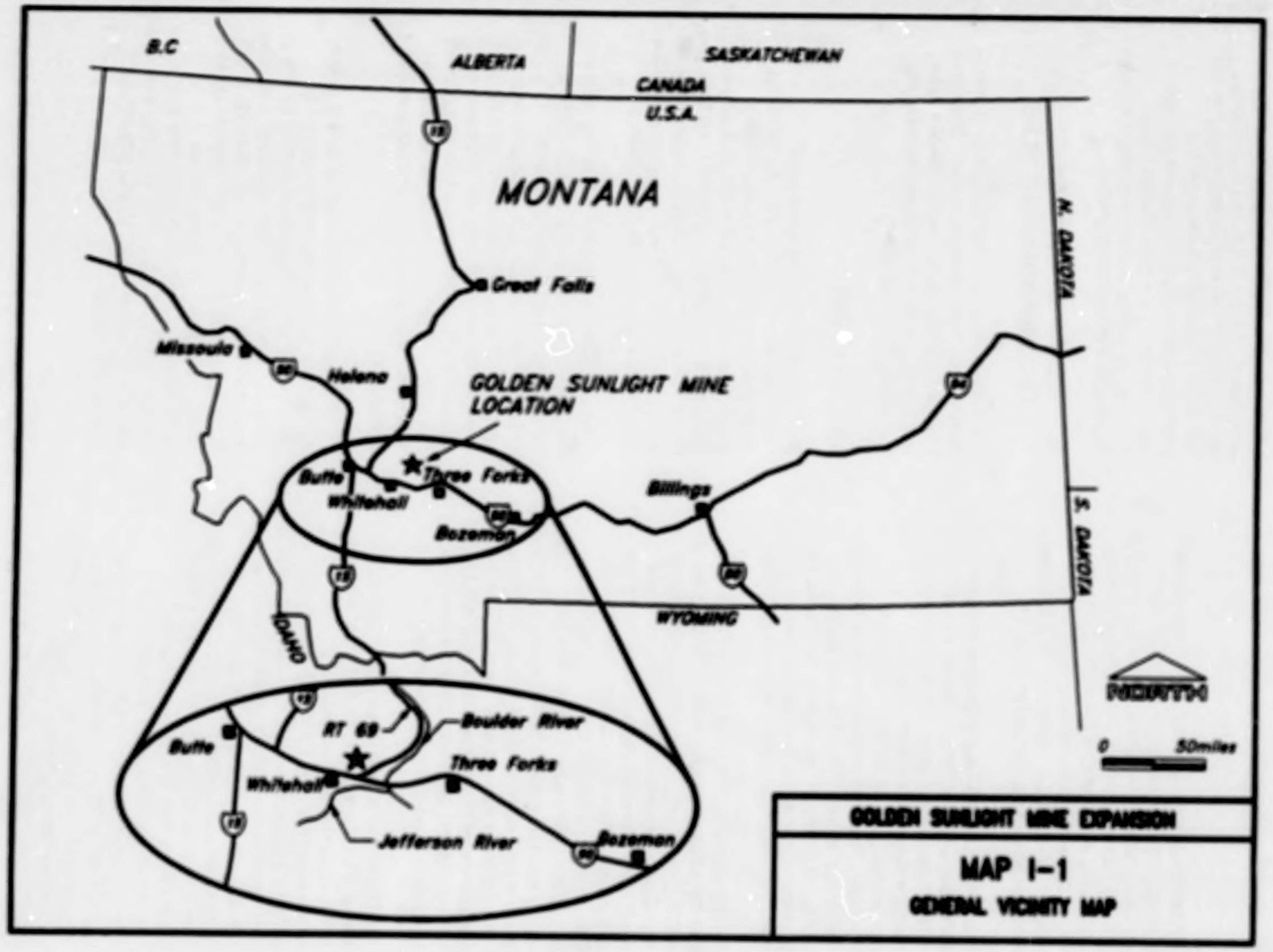
The GSM project and permitting history is summarized in the sections below. Chapter II and the GSM Operating Permit (GSM 1995a) provide additional details regarding on-going operations at the mine site.

I.A.1 Pre-1983

Mineral exploration and small-scale underground mining were conducted at the mine site from 1890, when gold was first discovered, until 1958, when the property was acquired by American Exploration and Mining, Inc. (the predecessor of GSM). Approximately 57,000 ounces of gold were produced from the project area prior to 1958 (GSM 1995b).

American Exploration and Mining, Inc. retained the property for 25 years before process technologies and gold prices allowed economic extraction from the low-grade, large-tonnage resource. Exploration and pre-development activities intensified during the 1970s and on June 27, 1975, GSM received Operating Permit No. 00065. Heap leaching of the sulfide ore was tested and proved unsuccessful during this period.

In 1980, significant expansion of mining activity by cyanide vat leaching was proposed as Amendment 001. After completion of an EIS in 1981, Amendment 001 was approved and GSM was authorized to construct an open pit, a mill, a tailings impoundment, and a cyanide vat leach facility. Construction of the tailings impoundment (Tailings Impoundment No. 1, on Map I-2) began in 1982. The first gold was poured in February 1983 after a $50 million capital investment.



GOLDEN SUNLIGHT MINE EXPANSION

MAP I-1

GENERAL VICINITY MAP

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I.A.2 1983 to June 1990

Several minor permit amendments were approved by MDSL and BLM during the period from 1983 to June 1990. During 1988, GSM applied for an amendment to the Operating Permit (Amendment 008) for a major mine expansion. MDSL and BLM evaluated the expansion in a mitigated Environmental Assessment (EA) under the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA).

I.A.3 July 1990 to December 1994 (Amendment 008)

On July 1, 1990, after completion of a mitigated EA by MDSL and BLM, GSM was authorized to continue mining under Amendment 008. Mining and ore processing continued under Amendment 008 with 31 stipulations attached to the Record of Decision (ROD) for the EA. The 31 stipulations and GSM's compliance with those stipulations are described later in this chapter. As part of Amendment 008, GSM was authorized to build a second tailings impoundment (Tailings Impoundment No. 2 on Map I-2), expand waste rock dumps, and expand the pit.

From 1990 through 1994, 25 minor amendments to GSM's Operating Permit were authorized by the agencies. Minor amendments are defined as changes in mine operations that do not have a significant effect on the human environment (MCA § 82-4-303(2); ARM § 26.4.101B[13]). Amendment numbers were assigned beginning in 1990, and are listed in the Operating Permit (GSM 1995a). The amendments were required so that GSM could respond to changes in environmental conditions, ore grade, maintenance and monitoring requirements, and regulatory parameters.

I.A.3.a Interior Board of Land Appeals Decision

An appeal of BLM's approval of Amendment 008 was filed with the U.S. Department of the Interior, Board of Land Appeals (IBLA) in Washington, D.C. by the National Wildlife Federation, Montana Environmental Information Center, Mineral Policy Center, and Sierra Club on September 13, 1990. The appeal alleged that BLM did not comply with several federal laws including NEPA, the Endangered Species Act, and the Migratory Bird Treaty Act.

On April 14, 1993, the IBLA ruled largely in favor of BLM. The IBLA stated: "Review of the record in this case including the EA (Environmental Assessment), the analysis of responses thereto, and the stipulations developed as a result of this process, discloses that officials of MDSL and BLM, as well as the permittee, have made impressive efforts to ensure successful reclamation of lands disturbed by this massive mining operation and to avoid significant adverse environmental impacts." The IBLA also ruled that two of the plaintiffs had no standing in the case.

The IBLA did request that BLM determine whether additional bonding was necessary for the possible reconstruction of several reclamation test sites. As a result, the BLM and MDSL reviewed GSM's bonding and issued a decision requiring an additional $443,000 bond. GSM posted the bond on June 27, 1993.

I.A.3.b Montana District Court Decision

An appeal of MDSL's approval of Amendment 008 was filed with the Montana First Judicial District Court, Lewis and Clark County, on March 30, 1992. The Gallatin Wildlife Association joined the plaintiffs listed above for the appeal. After 2 years of legal proceedings, the District Court Judge ruled on September 1, 1994, that MDSL must prepare an EIS that thoroughly evaluates potential environmental impacts associated with Amendment 008. The court determined that it was improper for MDSL to base its approval of Amendment 008 on the 31 stipulations listed in the ROD for the EA. The court ruled that:

- MDSL could not rely on Mitigation Measures that were neither included nor evaluated in the EA; and

- Since stipulations contained in the ROD relied on on-going studies, monitoring, and revised plans, the conclusion that these actions would reduce impacts to the level of insignificance was unsubstantiated, arbitrary, and capricious.

After the court ruling in September 1994, the plaintiffs, MDSL, and GSM negotiated a Settlement Agreement that allowed mining to continue under Amendment 008 until the completion of an EIS. The Settlement Agreement also provided for the formation of a committee composed of MDSL, GSM, and the plaintiffs to oversee the preparation of the EIS.

I.A.3.c Investigation of Ground Movement

During mid-1994, GSM voluntarily suspended operations after ground movement was detected in portions of the pit, and beneath the mill and East Waste Rock Dump. Ground movement was initially expressed as a series of small cracks in and around the plant site. After suspending operations, an extensive investigation was conducted to identify the nature and extent of the ground movement and to develop remediation measures to stabilize mine foundation materials. Geotechnical studies were conducted consisting of geologic mapping, drilling, surface and subsurface monitoring, hydrologic investigations, laboratory testing, and stability analyses. A list of geotechnical studies of ground movement is provided in the Operating Permit (GSM 1995a). The cause of the movement was diagnosed and stabilized in approximately 4 months. Another 3.5 months were spent completing secondary containment facilities and repairing the mill.

Based on the geologic and geotechnical studies, it was determined that the movement occurred on a pre-existing failure plane as much as 300 feet below the surface. Movement was initiated by the load created from the mine waste rock dumps. The failure plane occurs along the upper contact of the lower unit of the sedimentary geologic formation Tertiary-age Bozeman Group. Movement took place between the clay-rich lower unit and the overlying, more cohesive upper unit of the Bozeman Group. The dimensions of the area of movement are approximately 1.0 mile by 1.4 miles, and include over 300 million tons of material (Foster and Smith 1995; Golder Associates Ltd. 1995a).

I.A.3.d Stabilization and Remediation Efforts

During 1994, the upper Bozeman unit moved approximately 2 to 4 feet prior to completion of stabilization measures. Movement ceased after GSM excavated approximately 8 million tons of waste rock from near the head of the failure. An additional 7 million tons of waste rock were removed from the dumps to further improve stability (Golder Associates Ltd. 1995a). Approximately 3.5 of the 15 million total off-loaded tons were placed at the toe of the failure as a "buttress" to enhance stability (Map I-2). The remaining 11.5 million tons were placed on stable ground northeast of the area of the movement.

Numerous repairs and modifications were made to the ore-processing facilities after the ground movement was stabilized. Features such as flexible joint sealant and flexible pipe couplings were incorporated into the ore processing facilities to accommodate minor ground movement. In addition, an extensive monitoring system was installed in the mine and plant area to detect minor movement (GSM 1995a, Appendix 5).

Stabilization measures were permitted incrementally. During the stabilization effort, 10 revisions to the mine Operating Permit were approved to mitigate or study ground movement. These stabilization, repair, and monitoring programs were authorized as minor permit revisions (GSM 1995a). Ore-processing operations resumed in February 1995, after agency approval.

I.A.3.e Stabilization Efforts - Pit and Waste Rock Dump Modification

Although movement was arrested by the unloading of waste rock and the construction of the buttress, continued waste rock deposition required modification of GSM's waste rock dumping operations. Waste rock was no longer placed at the head of the slide block, and waste rock dumps were redesigned to improve stability. Open pit and waste rock dump design revisions are described in detail in Section II.B.1.a, Current Mining Operations. Stability monitoring and contingency plans also are described in Section II.B.1.a, Current Mining Operations.

I.A.4 January 1995 to 1997 (Interim Dump Plan)

Mining, ore processing, and tailings disposal continue at the mine site under the *Interim Dump Plan*, which was approved by the newly formed MDEQ as two minor permit revisions in 1995 and 1997. The *Interim Dump Plan* allows GSM to continue mining through the EIS preparation period in accordance with the Settlement Agreement by providing alternative waste rock dump space within the existing permit boundary. Alternative waste rock dump space was needed because stability concerns prohibited GSM from depositing waste rock in areas originally designed as waste rock dumps under Amendment 008. Waste dump designs were revised in the *Interim Dump Plan* so that ground movement would not be reactivated. The *Interim Dump Plan* provides for 136 acres of alternate waste rock dump space in the buttress area. Under current production rates, the permitted waste rock disposal capacity will be filled in late 1997 or 1998.

Waste dumps and other facilities authorized by Amendment 008 and the *Interim Dump Plan* are shown as existing mine facilities in Map I-2 and described in detail in the Operating Permit (GSM 1995a). Other minor permit revisions during 1995 described in the Operating Permit include construction of a drill core storage building and replacement of underground fuel tanks with above-ground fuel tanks (GSM 1995a). Minor revisions in 1996 include: new monitoring well and geotechnical hole locations; waste rock dump expansion; approval to use borrow material for capping the off-loaded East Waste Rock Dump; and, approval to use a snow cat to seed and fertilize reclamation slopes rather than hydromulching.

I.A.5 Operations Under Existing Mine Permits

The Operating Permit summarizes operations under the existing mine permit (Operating Permit 00065) and its amendments (GSM 1995a). The Operating Permit provides maps of existing operational areas and facilities, and the text describes the operation, monitoring, mitigation, reclamation, and closure plans. Permit amendments and revisions, including the 31 stipulations of Amendment 008, also are described in the Operating Permit. Measures that have been implemented to meet requirements of the stipulations are discussed later in this chapter, and in GSM's Annual Reports.

The existing environmental conditions at the mine site are dominated by mine-related activities, including open-pit mining, waste rock disposal, ore processing, and tailings disposal. The pit lies just east of the topographic divide of Bull Mountain and encompasses an area of approximately 312 acres. Currently, the pit bottom is at an elevation of 5,225 feet. Approximately 29.0 million tons of ore were processed through the end of 1995. The *Interim Dump Plan* allows for processing an additional 5.1 million tons of ore while limiting disturbance to existing permit boundaries. Total surface disturbance at the end of the *Interim Dump Plan* (circa late 1997) within the existing approved permit boundary is estimated to be approximately 2,336 acres.

Exploration, geotechnical, and groundwater monitoring investigations at the mine site continue in accordance with Exploration License 000297. Approved activities under the exploration license plan for the next 4 years (until 2000) include:

- Geological mapping;
- Geologic, geophysical, and geochemical testing;
- Exploration, geophysical, and condemnation drilling;

- Groundwater monitor well drilling;
- Drilling to define and characterize suitable reclamation materials;
- Drilling to evaluate geotechnical stability;
- Installation of inclinometers;
- Excavation of geotechnical, geophysical, and exploration trenches and test pits; and
- Road construction for drilling and trenching.

Additional details are provided in GSM's exploration plan (GSM 1995d).

I.B COMPLIANCE WITH THE SEPTEMBER 1, 1994, COURT ORDER AND FEBRUARY 7, 1995, SETTLEMENT AGREEMENT

I.B.1 Stipulation Compliance

The 31 stipulations attached to Amendment 008 approval included a variety of actions to mitigate impacts associated with the mine; these are listed in the Operating Permit (GSM 1995a). The stipulations and compliance status are provided in Table I-1. All stipulations have either been implemented by GSM or commitments have been made by GSM to address the recommended Mitigation Measures.

I.B.2 Issues Pertaining to the Montana Environmental Policy Act

The District Court identified four categories of potential impacts that were not adequately analyzed in the 1990 EA:

- Potential impacts from waste rock dump slopes constructed and reclaimed at a slope angle ratio of 2 horizontal to 1 vertical (2:1);

- Potential impacts from acid water vapor rise in the tailings impoundment and waste rock dumps;

- Potential impacts to surface and groundwater quality from acid rock drainage (ARD) and heavy metals; and

- Potential impacts associated with perpetual waste water treatment.

Each of these impacts had the potential to become significant, and MDSL and BLM had developed stipulations in 1990, prior to the approval of Amendment 008, to address these impacts. However, the effectiveness of these stipulations was not evaluated in the 1990 EA. This section presents a summary of the impacts, the effectiveness of the stipulations that apply to them, and a cross reference to the sections in Chapter IV that discuss the impacts in detail.

I.B.2.a Potential Impacts from Waste Rock Dump Slopes Constructed and Reclaimed at a Slope Angle Ratio of 2 Horizontal to 1 Vertical (2:1)

The Court concluded that MDEQ did not adequately document that reclamation would be successful on waste rock dump slopes constructed and reclaimed at a slope angle ratio of 2 horizontal to 1 vertical (2:1), and that MDEQ did not adequately evaluate the potential environmental impacts resulting from reclamation failure of 2:1 waste rock dump slopes.

GSM proposes to construct and reclaim waste rock dumps at a combination of 2:1 and 3:1 slope angle ratios (GSM 1995a; GSM 1995b). Potential environmental impacts to soils, vegetation, wildlife, surface water, and groundwater resources could result if waste rock dump reclamation is not successful at the proposed slope angle ratios of 2:1 and 3:1. Reclamation success of the waste rock dump slopes is highly dependent upon: 1) soil erosion rates, and 2) the ability of vegetation communities to establish and maintain themselves under the existing climatic conditions at the mine. The success potential of revegetating 2:1 and 3:1 slopes is discussed in detail in Chapter IV, Soils and Reclamation.

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Table I-1

Status of Stipulation Compliance

Stipulation Requirement	Action by GSM	Commitments or Status	Cross-Reference to Chapter IV
1. Reclaim waste dump slopes concurrent with operations.	Reclamation of waste dump slopes is underway where possible.	Continue reclamation concurrent with operations wherever possible.	See Chapter IV, Soils and Reclamation
2. Research and monitoring of waste dump reclamation capping.	Reclamation test plots were designed and analyzed according to agency parameters. Results reported annually from 1991 to 1995.	Summary of reclamation test plot analyses are given in Permit Application Volume 4, App. 5.5-1 (Schafer and Associates Ltd. 1995a); Volume 5, App. 5.5-2 (Schafer and Associates Ltd. 1995b); Volume 5, App. 5.6-2 (Richardson 1995), and the 1995 Annual Report (GSM 1996a).	See Chapter IV, Soils and Reclamation See Chapter IV, Water Resources
3. Construct drainage or seepage control structures below waste rock dumps.	Retention berm construction completed concurrent with soil stripping. As-builts submitted in annual reports.	Retention berm construction to continue concurrent with soil stripping.	See Chapter IV, Water Resources
4. Engineer diversions capable of handling 100-year, 24-hour precipitation events around reclaimed dumps.	Design information supplied in GSM Annual Report submitted in March 1992.	Agency letter dated July 2, 1992, states that stipulation is fulfilled. Implementation of plans will take place during final reclamation of each waste rock dump.	See Chapter IV, Water Resources

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Table I-1 (Continued)

Stipulation Requirements	Action by GSM	[illegible]	[illegible]
5. Evaluate and report the acid-producing potential and lime requirements of waste rock dump surfaces after slope reduction.	Sampling program outlined in reclamation plan given in Appendix D of the GSM Annual Report submitted in March 1992. Sampling and test results will determine placement of oxidized cap rock and/or lime amendments.	Summary of reclamation test plot analyses are given in Permit Application Volume 4, App. 5.5-1 (Schafer and Associates Ltd. 1988a); Volume 5, App. 5.5-2 (Schafer and Associates Ltd. 1988b); Volume 5, App. 5.6-2 (Richardson 1988); and the 1988 Annual Report (GSM 1989a). Reports of sampling are given in the Annual Reports.	See Chapter IV, Soils and Reclamation See Chapter IV, Water Resources
6. Evaluate and report the acid-producing potential and lime requirements of oxidized waste rock cap during placement.	Sampling program outlined in reclamation plan given in Appendix D of the GSM Annual Report submitted in March 1992.	Sampling and test plot results are given in GSM's Annual Reports.	See Chapter IV, Soils and Reclamation See Chapter IV, Water Resources
7. Sample soil after placement on re-contoured waste rock dumps.	Sampling program outlined in reclamation plan given in Appendix D of the GSM Annual Report submitted in March 1992.	Sampling results are given in GSM's Annual Reports.	See Chapter IV, Soils and Reclamation
8. Design and monitor erosion control systems to minimize soil loss from waste dump slopes.	Erosion control systems developed in conjunction with Stipulation No. 4.	Agency letter dated July 2, 1992, states that stipulation is fulfilled. Implementation of plans will take place during final reclamation of each waste rock dump.	See Chapter IV, Soils and Reclamation
9. Submit a revised dumping plan for agency approval with decommissioning schedule and plans for waste dump reclamation concurrent with operations.	Dump designs and dump reclamation plans and schedules were submitted to the agencies.	Agency letter dated July 2, 1992, states that stipulation is fulfilled if GSM supplies volumes of oxide rock and soil salvage in GSM's Annual Reports. The information is being provided annually.	See Chapter IV, Soils and Reclamation

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Table I-1 (Continued)

Stipulation Requirements	Action by GSM	Commitments or Status	Cross-Reference to Chapter IV
10. Evaluate methods of minimizing movement of acidic water to the tailings embankment face.	GSM evaluated methods and presented results in GSM's Annual Reports submitted in 1991 and 1992.	Agency letter dated July 2, 1992, states that stipulation is fulfilled.	See Chapter IV, Water Resources
11. Initiate, monitor, and report results of the cycloned tailings reclamation test plot.	GSM's tailings impoundment test plots determined by agencies to be relevant to the sand tailings reclamation.	Agency letter dated July 2, 1992, states that stipulation is fulfilled.	See Chapter IV, Soils and Reclamation
12. Place 18-inch low-permeability layer in two compacted lifts over final tailings surface. Alternatives to the soil layer can be presented based on GSM studies.	GSM constructed test plots on tailings surface in 1992 to evaluate alternative methods to the clay cap.	Testing results are provided in Permit Application Volume 5, App. 5.6-1 (Dollhopf et al. 1993).	See Chapter IV, Soils and Reclamation
13. Develop a monitoring plan for Impoundment No. 1 designed to quantify seepage and effectiveness of reclamation in limiting seepage.	Reclamation test plots developed in 1992.	Testing results are provided in Permit Application Volume 5, App. 5.6-1 (Dollhopf et al. 1993).	See Chapter IV, Soils and Reclamation See Chapter IV, Water Resources
14. Monitoring of Impoundment No. 1 pumpback wells and reclamation effectiveness in limiting seepage must continue until water quality standards can be met.	Impoundment No. 1 pumpback wells monitored.	Monitoring will continue until no longer required by the agencies.	See Chapter IV, Water Resources
15. Pumpback wells for Impoundment No. 1 must operate and discharge into Impoundment No. 2 during mine life. After mine life, wells must be pumped to a treatment plant or other facility designed to meet water quality standards.	Impoundment No. 1 pumpback wells will be discharged to Impoundment No. 2.	GSM has committed to treat water as necessary after mine closure.	See Chapter IV, Water Resources

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Table I-1 (Continued)

Stipulation Requirements	Action by GSM	Commitments or Status	Cross-Reference to Chapter IV
16. Submit specifications for tailings impoundment diversion structures. Annual maintenance required and cost for maintenance upon reclamation must be determined.	Design reports submitted in 1991 and 1995. Impoundment No. 2 diversion completed in 1991. Impoundment No. 1 diversion to be completed in 1997.	Annual maintenance, if required, will be completed and costs are being tracked beginning in 1996.	See Chapter IV, Water Resources
17. Submit a final grading plan in 1991 annual report to distribute runoff across the reclaimed impoundment surfaces.	Plan provided in GSM's Annual Report submitted in March 1992.	Agency letter dated July 2, 1992, states that stipulation is fulfilled.	See Chapter IV, Water Resources
18. Initiate test plot on tailings Impoundment No. 1 to test reclamation plan and alternative reclamation plans regarding limiting seepage.	Test plots constructed during 1992 on Impoundment No. 1.	Testing results are provided in Permit Application Volume 5, App. 5.6-1 (Dollhopf et al. 1995).	See Chapter IV, Soils and Reclamation See Chapter IV, Water Resources
19. Pit water balance must be monitored quarterly and submitted to the agencies. Pit inflow measurements must be submitted in the annual reports.	GSM is monitoring pit seepage (inflow) on a monthly basis.	Inflow measurements are provided in GSM's Annual Reports.	See Chapter IV, Water Resources
20. Bonding for a water treatment facility must be submitted when the pit intersects the anticipated water table.	Water treatment plans were provided in GSM's Annual Report submitted in 1992. Cost tables were modified in 1993. Bond was submitted in 1993. Agencies reviewed data submitted in Stipulation 19, and bond was increased in June 1996 because of increased inflows.	GSM requested in Annual Report submitted in 1994 that any future bond adjustments related to water treatment coincide with the submission of the annual (June 27) incremental reclamation performance bond.	See Chapter IV, Water Resources

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Table I-1 (Continued)

Stipulation Requirements	Action by GSM	Commitments or Status	Cross-Reference to Chapter IV
21. Where possible, use tree plantings on benches and talus slopes of final pit walls.	Test plantings for pit bench reclamation are described in GSM's Annual Report submitted in 1993.	GSM will plant trees on accessible, safe portions of the pit walls as areas are vacated and if materials are suitable.	See Chapter IV, Vegetation and Wetlands
22. Structures must be constructed to divert water around the pit.	Diversion designs were presented in GSM's Annual Report submitted in March 1992.	Agency letter dated July 2, 1992, states that stipulation is fulfilled.	See Chapter IV, Water Resources
23. Develop a plan to identify the potential for vertical flows and fracture flows from the pit.	Plan to identify flows from the pit included with GSM's Annual Report submitted in June 1991.	Agency letter dated July 2, 1992, states that stipulation is fulfilled.	See Chapter IV, Water Resources
24. At the end of mine life, review water treatment plan to determine if modification necessary.	Monitoring programs being completed on pit, waste dumps, and tailings.	GSM will review treatment plan at the end of mine life using monitoring information. Modifications will be made as necessary.	See Chapter IV, Water Resources
25. Submit additional bond totaling $1,158,000 for the 12 years through and including 2002. For 2003 and 2004, $408,000 must be submitted, unless these amounts are revised by future bond evaluations. Other requirements are listed for the Annual Reports.	Reclamation bond is increased annually as directed.	GSM Annual Reports include all of the information required by the stipulation.	See Chapter IV, Water Resources

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Table I-1 (Continued)

Stipulation Requirements	Action by GSM	Commitments or Status	Cross-References to Chapter II
26. Test areas with the potential to acidify at the end of operations. Cover and revegetate areas with acidification potential, or channel drainage from these areas to a treatment facility, where necessary. Includes haul roads and material spillage areas.	GSM is performing as much reclamation as possible prior to mine closure.	GSM will test areas with acid-producing potential at the end of mine life. Necessary measures will be taken to revegetate or channel drainage from these areas.	See Chapter IV, Soils and Reclamation
27. All studies identified in stipulations above must clearly define objectives, deliverables, and schedules. Monitoring results and recommendations must be discussed in annual meetings with MDEQ, BLM, and WQB.	Study objectives, deliverables, and schedules for studies were identified by GSM. Numerous meetings and site visits are conducted with the agencies annually.	Results of the test plots have been reported in GSM annual reports and in the Permit Application Volumes 4 and 5.	N/A
28. Submit a final plan which identifies objectives, deliverables, and due dates for all reclamation test plots.	Reclamation test plot plan was provided in GSM's Annual Report submitted in March 1992.	Agency letter dated July 2, 1992, states that stipulation is fulfilled.	N/A
29. Submit a revised, consolidated operating and reclamation plan which reflects all of the documents identified in the first paragraph of this amendment, as well as designs and plans required in the stipulations above.	Plans were provided in GSM's Annual Report submitted in 1992. All required information was incorporated in the operating and reclamation plan.	Modifications to the plan will be provided in GSM's Annual Reports and Operating Plan as necessary.	N/A

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Table I-1 (Continued)

Stipulated Requirements	Action by GSM	Commitments or Status	Cross-Reference to Chapter IV
30. Studies, plans, or specifications required by stipulations must be submitted to MDFQ and BLM. Approval required for implementation.	No actions have been taken by GSM regarding the stipulation prior to submittal and approval of the plans by the agencies.	GSM will continue to modify its mine and reclamation plans as additional research is completed. Results of the test plots have been reportnd in GSM annual reports and in the Permit Application Volumes 4 and 5.	N/A
31. Complete a Level III cultural resource survey on the north half of Section 29, T2N, R3W.	The Level III survey was completed and submitted to DSL in November 1990.	Agency letter dated July 2, 1992, states that stipulation is fulfilled.	See Chapter IV, Cultural Resources

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Studies conducted by GSM from 1991 to 1994 to implement stipulations 2, 5, 6, 7, and 8 showed that soil erosion rates remained in the acceptable range (less than 2.0 tons per acre) when high coarse rock fragment content soil material (50 percent coarse fragments by volume) was used in combination with the oxidized waste rock cap and additional erosion control, revegetation, and quality control measures proposed by GSM (contour benching, dozer gouging, mulching, intensive material sampling, etc.). Under the climatic conditions existing at the mine site from 1991 to 1994, vegetation cover established on reclaimed 2:1 and 3:1 waste rock dumps exceeded the cover on established reference areas adjacent to the mine. It must be noted, however, that during 1993, 1994, and 1995 the mine site received above average precipitation that enhanced revegetation of the reclaimed slopes (see Chapter IV, Soils and Reclamation).

I.B.2.b Potential Impacts from Acid Water Vapor Rise in the Tailings Impoundment and Waste Rock Dumps

The Court concluded that MDEQ did not adequately evaluate the effect of acid water vapor rise on revegetation and reclamation success of the tailings impoundment and waste rock dumps.

The potential for capillary rise (upward migration of acid water products) was addressed in studies completed at the mine site by Schafer and Associates Ltd. (1995a) and Dollhopf et al. (1985). These studies are discussed in detail in Chapter IV, Soils and Reclamation. Where assessments of upward migration of acid products in the waste rock dump cap could be made, it appeared that upward migration was limited to a maximum of 4 inches (Schafer and Associates Ltd. 1995a). Dollhopf et al. (1985) inferred that migration of contaminants from the tailings upward into the coversoil was not occurring on the test plots evaluated. In addition, Barth (1988) noted that capillary rise in spoil or tailings systems at other sites under a variety of climatic conditions is typically limited, and ranges from 2 to 8 inches. Assuming a "worst-case" of capillary rise of 8 inches, the reclamation cap depth proposed for the waste rock dumps (43 to 48 inches) and tailings impoundment (48 inches) should continue to support vegetation.

I.B.2.c Potential Impacts to Surface and Groundwater Quality from Acid Mine Drainage (ARD) and Heavy Metals

The Court concluded that MDEQ did not adequately evaluate the potential impacts to surface and groundwater quality from acid rock drainage (ARD) and heavy metals migrating out of the waste rock dumps, tailings impoundment, and pit.

A thorough evaluation of potential impacts to surface and groundwater from ARD and heavy metals is provided in Chapter IV, Water Resources. A summary of these impacts is provided below.

Waste Rock Dumps

No impacts to surface water or groundwater quality are anticipated during active mining operations. Model estimates predict that ARD generated from the existing waste rock dumps will have impacts to groundwater quality in the vicinity of the waste rock dumps, although the time before these impacts are experienced at locations of beneficial uses is estimated to be on the order of tens to hundreds of years. The incremental impact to surface water and groundwater quality from proposed new waste rock dumps constructed under the Proposed Action and other action alternatives is expected to be negligible compared to existing conditions. Under estimated (modeled) conditions, the Water Management Plan presented in Appendix A will prevent ARD impacts downgradient from the waste rock dumps from migrating outside of the proposed mixing zone boundary (see Appendix B). Springs within the proposed mixing zone boundary are likely to be impacted by ARD, and/or by drawdown effects from the capture well system that is part of the long-term water management plan presented in Appendix A. Mitigation of impacts to wildlife use of springs within the proposed mixing zone boundary are described in Mitigation Measures W-1 and W-5 (see Section IV.P, Potential Mitigation and Monitoring).

Tailings Impoundments

Tailings water quality in Tailings Impoundment No. 1 is currently slightly alkaline (pH = 8.1) and contains cyanide concentrations on the order of 30 to 80 mg/L (DSM 1996a [1995 Annual Report]). The process of decommissioning Tailings Impoundment No. 1 began in 1993, and complete dewatering is expected to be completed in 8 to 10 years. Cyanide concentrations in the pumpback water are expected to decrease during the 10-year dewatering period.

Impacts to water quality from Tailings Impoundment No. 1 are associated with the discharge of process water which contains cyanide. Tailings Impoundment No. 1 has impacted groundwater below the impoundment and downgradient. A series of pump back wells intercepts and contains the cyanide plume, as described in Section III.B.2.l, Groundwater in the Tailings Impoundment Areas. Cyanide levels are no longer detectable in several downgradient private wells, indicating that the pumpback system has limited cyanide migration. Cyanide degradation products as well as other process water constituents (nitrate and total dissolved solids) are still detected downgradient of the impoundment. Downgradient monitor wells OW-2, OW-3, OW-4, OW-7 and OW-10 in the past have shown the impacts of process water from Tailings Impoundment No. 1.

Under the current reclamation plan, the tailings impoundments will be reclaimed by dewatering, consolidation, grading, capping, and revegetating the surfaces. Capping under the No Action Alternative will consist of a 24-inch soil material cap on top of 18 inches of a clay layer on top of 24 inches of local borrow. Research on Tailings Impoundment No. 1 (Dollhopf 1995) indicates the capping system does not exclude oxygen. Therefore, in time, the tailings will acidify providing a potential for ARD. Potential adverse impacts to water quality are dependent upon the amount of water infiltrating the reclaimed caps, which will be a source for ARD formation and groundwater loading. Results reported by Dollhopf and others (DSM 1996b) indicate that long-term infiltration of direct precipitation through the tailings impoundment cover will be small to negligible under the No Action Alternative. Thus, under the No Action Alternative little if any impact to groundwater is anticipated once dewatering of the impoundments is complete.

The tailings reclamation cap for the Proposed Action and other action alternatives differs from the No Action Alternative. Under the Proposed Action and other action alternatives, the reclamation cap would utilize 24 inches of top soil placed upon 24 inches of local borrow (no clay layer would be utilized). Results from the long-term modelling (30-year average), predict a long-term infiltration rate of 0.25 inch per year. Because of the infiltration associated with this reclamation cap, seepage from Tailings Impoundment No. 1 would continue to occur even after the tailings have consolidated. This seepage may be ARD in character and possibly contain cyanide concentrations in the short-term. However, the low quality seepage would be intercepted by the groundwater pumpback system and routed to the treatment facility. Thus, any water quality impacts would be confined to the immediate vicinity of Tailings Impoundment No. 1.

Tailings Impoundment No. 2 was built with a synthetic liner to prevent the downward migration of contaminants. Localized failure (leaks) in the liner under Tailings Impoundment No. 2 are likely to occur over the long-term. However, the total amount of water in Impoundment No. 2 will be gradually reduced through the recycling and evaporation process until the rate of consolidation and drainage is greatly reduced. Considering the overall reduction in the rate of seepage with time, it is anticipated that groundwater impacts attributed to the small amount of tailings water that manages to seep through isolated leaks in the liner will be negligible.

Pit

Water that collects within the mine pit will have a significant potential to form ARD. However, during operation, water that collects in the pit is treated and recycled in the ore processing circuit. Pumping of water from the pit causes a cone of depression in the groundwater table surrounding the pit, such that most of the net flow is into the pit. Thus, ARD from the pit is not expected to impact the local groundwater environment during operation. Because the pit will be maintained as a local groundwater sink after reclamation, and pit water will continue to be collected and routed to a treatment facility before being discharged, no impacts to groundwater quality are anticipated long-term.

I.B.2.d Potential Impacts Associated with Perpetual Waste Water Treatment

The Court concluded that MDEQ did not adequately evaluate the effectiveness or the potential environmental impacts associated with perpetual waste water treatment.

Plant Design and Treatment Capacity

Under the reclamation plan, a permanent water treatment plant will be constructed to treat contaminated water from the pit, tailings impoundments, and miscellaneous small-quantity sources (GSM 1995a). The treatment plant design originally submitted under the permit application (GSM 1995a, Appendix 12) was revised in August 1996, to accommodate greater inflows from the Tailings Impoundment No. 1 groundwater pumpback system, and to treat poorer water quality than the original treatment plant. The design was again revised in July 1997, to accommodate, in addition, potential inflows from a West Waste Rock Dump groundwater capture well system, plus contingencies, as described in the Long-Term Water Management Plan (see Appendix A). The new treatment facility will combine the treatment of tailings, waste dumps, and pit water in a single process and is currently designed to accommodate inflows of up to 316 gpm.

Sludge Disposal

The water treatment process will generate sludge, to be dewatered in a filter press and then pumped to a sludge disposal area. The sludge disposal plan was revised in November 1996, to accommodate greater inflows and poorer water quality than the original sludge disposal plan (see Appendix C). Sludge produced from the permanent water treatment plant is to be landfilled within Tailings Impoundment No. 2., which will provide adequate storage area for over 1,000 years of sludge production at projected production rates. Should sludge storage be required beyond this capacity, additional storage in Tailings Impoundment No. 2 would need to be provided for, or an alternative disposal site would need to be identified.

Protection of the groundwater system from any potential leachate from the sludge will be provided by the HDPE liner to be placed over the surface of Tailings Impoundment No. 2 prior to sludge disposal. The existing liner below Tailings Impoundment No. 2 will provide secondary protection against leakage of leachate from the sludge. Once sludge placement is completed in a given sludge cell, the surface of the cell will be covered with a geomembrane liner and reclaimed to prevent infiltration of surface water into the sludge. Due to the lining to be provided in each cell, impacts to groundwater quality from sludge production is not anticipated.

Protection of wildlife from exposure to sludge will be provided by wildlife control fences and bird netting over the reclaim ponds. Surface water from active sludge cells will be collected and routed through the permanent water treatment plant. Consequently, the only potential impacts to wildlife or water quality from sludge production would occur as a result of failure of the wildlife control measures or treatment plant process systems. Treatment plant failure resulting in environmental degradation is considered unlikely because the system is automatically monitored, and will have an on-site operator.

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Other Long-Term Impacts

Other long-term effects of the permanent water treatment plant include periodic replacement of plant components. Over the expected life (in perpetuity) of the water treatment processing, virtually all components of the plant would be expected to require replacement periodically. Bond requirements should include consideration of periodic reconstruction or replacement of treatment plant components. This replacement would not add any additional adverse environmental effects to the site beyond those associated with active construction and disposal of industrial equipment. Long-term environmental impacts of perpetual water treatment would include perpetual power consumption. Other perpetual impacts would be associated with required access and maintenance associated with haul roads, transport of materials, and consumption of treatment chemicals.

Reclamation Requirements

The permanent water treatment plant and associated sludge drying and disposal areas would require a total of 10.5 acres of new disturbance. Reclamation criteria for the water treatment facilities are provided in the Operating Permit (GSM 1996a, p. 23) and are identical to those provided for the waste rock dumps. Under the Proposed Action the treatment plant would be removed if it is no longer needed, and the foundations buried. The disturbed areas would be sloped to natural contours, covered with salvaged soil, and revegetated. The soil in sludge drying areas would be tested prior to seeding and, if necessary, soil amendments would be added to meet the standards for waste rock reclamation cover soil (GSM 1996b, pp. 5-11).

I.B.3 Issues Pertaining to the Montana Metal Mine Reclamation Act (MMRA) and Montana Constitution

The Montana District Court directed that the reclamation plan should be reevaluated regarding compliance with certain requirements of the MMRA, including:

- Simultaneous reclamation;
- Reclamation of "objectionable effluent";
- Pit reclamation; and
- Reclamation of the permanent water treatment plant, sludge landfill, and miscellaneous facilities.

I.B.3.a Simultaneous Reclamation

The Court directed MDEQ to document that reclamation activities shall be completed on abandoned portions of the mine within 2 years of abandonment, or issue an order granting an extension from the 2-year statutory period as required by the MMRA [MCA § 82-4-336(1)].

The existing reclamation plan and the reclamation plan for continued mining under the Proposed Action are described in Chapter II of this document. The existing reclamation plan also is described in detail in the Operating Permit (GSM 1996a, pp. 14-22a), while the reclamation plan for the Proposed Action is described in detail in GSM's Permit Application (GSM 1996b, pp. 5-1 to 5-13).

The reclamation schedule for mine facilities under the No Action Alternative and the Proposed Action is presented in Chapter II. All facilities will be reclaimed within 2 years of their abandonment. The agencies do not consider the tailings impoundment abandoned until tailings consolidation is complete. As portions of the impoundment dry and consolidation stops, the mine conducts concurrent reclamation on the accessible portions. When the tailings consolidation process is complete the mine would have two years to complete the reclamation as required by the MMRA.

Settling of slimes in the tailings impoundments will delay final reclamation of the tailings surface 8 to 10 years after ore processing stops (GSM 1996a, Appendix 12). The tailings can only be reclaimed after consolidation stops. The impacts of this delayed reclamation are evaluated in Chapter IV, Water Resources. GSM has not provided an adequate monitoring plan to address this delayed reclamation schedule. Agency-recommended monitoring would consist of establishing a surveyed 100- x 100-foot grid on the impoundment surface as soon as the tailings are dry enough to allow foot traffic. The surveyed grid would be monitored until settling ceases for 1 year at any particular survey point. Then GSM would have one summer season to complete the reclamation capping, establishing the required grade, soiling and fall seeding on the areas that have completed the consolidation process. The agencies will present this monitoring process and reclamation schedule in the Agency-Preferred Alternative.

OP-Map-16 contained in the Operating Permit, displays graphically the reclamation schedule for waste rock dumps under the No Action Alternative (GSM 1995a). Exhibit 5-2, contained in the Permit Application displays the same information for the Proposed Action. All waste rock dumps are scheduled to be reclaimed within 2 years of abandonment. The off-loaded East Waste Rock Dump in the landslide area is being reclaimed in 1996 and 1997. The South portion of the West Waste Rock Dump was scheduled for reclamation in 1995 and 1996. It has been delayed with the agencies' approval until the EIS is completed.

I.B.3.b Reclamation of "Objectionable Effluent"

The Court found that the reclamation plan in place in 1990, violated the MMRA [MCA § 82-4-336(9)] insofar as it neither provided for a reliable evaluation of the potential for groundwater contamination from the pit, tailings impoundment, and waste rock dumps, nor guarded against such contamination. The relevant provisions of Section 82-4-336(9) provide that when mining has left an open pit exceeding 2 acres of surface area and the composition of the floor or walls of the pit are likely to cause formation of acid, toxic, or otherwise pollutive solutions ("objectionable effluents") on exposure to moisture, the reclamation plan must include provisions which provide for:

a) Insulation of all faces from moisture or water contact by covering to a depth of 2 feet or more with material or fill not susceptible itself to generation of objectionable effluents; [OR]

b) Processing of any objectionable effluents in the pit before they are allowed to flow or be pumped out of the pit to reduce toxic or other objectionable ratios to a level considered safe to humans and the environment by the department; [OR]

c) Drainage of any objectionable effluents to settling or treatment basins when the objectionable effluents must be reduced to levels considered safe by the department before release from the settling basin; or

d) Absorption or evaporation of objectionable effluents in the open pit itself.

The potential for groundwater contamination from the pit, tailings, and waste rock dumps has been evaluated in Chapter IV of this document (see Chapter IV, Water Resources). The impact evaluation in Chapter IV suggests that regardless of whether mining ceases or continues at the mine site, there is potential for groundwater contamination over time from effluents generated by past mining activities.

To guard against potential groundwater contamination, the existing reclamation plan and the Reclamation Plan for the Proposed Action include provisions which provide for drainage of pit and tailings effluents to a permanent water treatment plant where they would be treated to meet Montana Water Quality Standards before being released into the surrounding environment. Appendix A provides design specifications for the permanent water treatment plant as well as a plan for long-term water management at the mine site. The plan provides for monitoring potential groundwater contamination at the toe of the waste rock dumps, collecting any contaminated effluent from waste rock seepage, and pumping the effluent to the permanent water treatment plant for treatment.

The design specifications and bonding calculations for construction and operation of the permanent water treatment plant are based

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an estimated outflow from the pit and seepage from the tailings impoundments (see Appendix A). The anticipated seepage and plan to collect and route seepage from the waste rock dumps to the treatment plant will be incorporated into bonding calculations for the *Agency Preferred Alternative*.

I.B.2.c Pit Reclamation

Article IX, Section 2(1) of the Montana Constitution provides: "All lands disturbed by the taking of natural resources shall be reclaimed." The Court found that Section 82-4-336(7) of the MMRA was in violation of Montana 's Constitution because it did not require reclamation of open pits and rock faces that may not be feasible to reclaim. The Court also found that despite the constitutional issues surrounding Section 82-4-336(7), MDEQ should have evaluated the feasibility of reclaiming the pit under the existing statute.

The Montana legislature has since amended Section 82-4-336(7) so that it now requires that open pits and rock faces must be reclaimed to a condition:

a) Of stability structurally competent to withstand geologic and climatic conditions without significant failure that would be a threat to public safety and the environment;

b) That affords utility to humans and the surrounding natural system to the extent feasible; and

c) That blends with the appearance of the surrounding area to the extent feasible.

Under the existing reclamation plan, approximately 53 acres of pit benches would be reclaimed by capping with oxidized waste rock and soil, and revegetating to blend with the surrounding area. Under the reclamation plan for the Proposed Action, approximately 19 acres of pit benches would be reclaimed. The remaining pit areas, including steeply sloped and inaccessible areas, would be reclaimed to highwall rockfaces. Both reclamation plans include provisions for reclaiming portions of the pit by creating habitat (rock cavities and roost sites) for raptors and bats.

The *Partial Backfill Alternative* presented in Chapter II of this document describes methods that could be used to backfill the pit bottom with waste rock, cap the waste rock with oxidized rock and soil, and revegetate the surface to blend with the surrounding area.

I.B.2.d Reclamation of the Permanent Water Treatment Plant, Sludge Landfill, and Miscellaneous Facilities.

The Court found that the reclamation plan in place in 1990 violated the MMRA [MCA § 82-4-336(5)], insofar as it did not provide for reclamation of the permanent water treatment plant, sludge landfill, and other miscellaneous facilities.

Both the existing reclamation plan (as revised since 1990) and the reclamation plan for the Proposed Action (GSM 1995b, pp. 5-1 to 5-13) outline reclamation goals and specific methods for reclaiming all mine facilities, including: 1) pit; 2) waste rock dumps; 3) tailings impoundment; 4) roads, utility corridors, and "facility" areas (including the plant site and water treatment plant); 5) miscellaneous "buffer zone" disturbances (including areas such as soil stockpiles, soil stripping areas, berms, and monitoring and pumpback wells); and 6) borrow area, wing dike, and diversion structures (GSM 1995a, pp. 14-23a). The reclamation plans do not specifically provide for reclamation of the sludge landfill. The reclamation plan for the sludge landfill associated with the water treatment plant is provided in GSM's revised sludge disposal plan submitted November 6, 1995 (Appendix C). The solid waste landfill located within the waste rock dumps would be reclaimed under the existing and proposed Waste Rock Dump Reclamation Plan.

I.C PURPOSE OF AND NEED FOR THE PROPOSED ACTION

I.C.1 Golden Sunlight Mine's Objectives

The Proposed Action would allow the continued operation of the mine site beyond its current permit boundaries. GSM's project objectives are as follows:

- Continue to extract and market economically recoverable gold and other minerals in the project area for currency, jewelry, and other applications described in Table I-2;
- Operate and reclaim mine areas in an efficient, environmentally conscientious, and safe manner to ensure long-term stability;
- Comply with the Montana District Court decision and all applicable state and federal statutes and rules; and
- Continue to enhance the economy and socioeconomic status of the area around the mine.

I.C.2 State of Montana's Responsibilities

I.C.2.a Montana Department of Environmental Quality

MDEQ administers MEPA, the MMRA, the Montana Hazardous Waste and Underground Storage Tank Act, and the Montana Air Quality Act and Water Quality Act. MDEQ is responsible for investigating the environmental impacts associated with continued mining in accordance with MEPA and the EIS process, and for evaluating the compliance with the MMRA. In addition, MDEQ is charged with evaluating the probable success or failure of each of the 31 stipulated Mitigation Measures attached to Amendment 008 approval, and the additional alternatives, impacts, and compliance measures identified in the stipulated settlement agreement dated February 7, 1995.

I.C.2.b Hard-Rock Mining Impact Board

The Hard-Rock Mining Impact Board, associated with the Montana Department of Commerce for administrative purposes, was created by passage of the Hard Rock Impact Act (Title 90, Chapter 6, Part 3, MCA). A quasi-judicial board, it is intended to act as a referee in hearing disputes between local government and large-scale mineral developers over the impact mitigation plan. The impact mitigation plan identifies the increased public sector costs associated with the mineral development and commits to pay, according to a specified time schedule, all increased capital and net operating costs to local government resulting from development. With a work force of over 200 employees, Golden Sunlight's mine has met the definition of a larger-scale mineral developer. However, it was permitted prior to the effective date of the Hard Rock Impact Act and was grandfathered from compliance.

I.C.2.c Montana Department of Natural Resources and Conservation

The Montana Department of Natural Resources and Conservation (MDNRC), Trust Land Management Division is responsible for administering all state school trust lands. It must approve all activities occurring on or affecting state school trust surface and/or subsurface (mineral estate) lands. These lands are managed to benefit the state school trust. Therefore, the MDNRC is concerned with any activity that would affect the ability of state minerals and/or state surface to be developed, particularly activities that would affect the potential to bring income to the state school trust. In addition, the MDNRC is concerned with activities which would impact the school trust land's asset value. For activities that would preclude further mineral extraction, the

Table I-2

Common Uses for Gold

Jewelry
Currency
Electronics • Alarm clocks, light switches, remote controls, microwave ovens, televisions, VCRs, circuit boards, computers, computer keyboards, touch-tone phones, computer and audio compact discs (providing signal quality).
Aerospace • Satellites: moving contact points, gyroscopes, antennas, control boxes, memory boards, and delicate instruments. • Space Shuttle: gold brazes, engine cooling system, impeller in fuel pumping system, cameras and photography. • Commercial and Military Jet Airplanes: joints in jet engine components, gold-coated mirrors, infrared jammers, gold coating on Air Force One (prevents detection by heat-seeking missiles).
Industry • Industrial Applications: gold-plated contacts, gold coatings, windows on skyscrapers to reflect infrared radiation. • Industrial Heating Ovens. • Nuclear Power Plants: gold alloy tubes in heat exchangers (gold helps prevent tubes from cracking). • High-security Buildings: to protect the building from x-rays and other intrusive devices. • Gold Alloy Catalysts: gold vinyl acetates are used to make transparent plastics for meat and vegetable packing. • Plant Control Systems: touch panels have a thin gold coating to conduct electrical current when the panel is touched.
Medical • Medical and monitoring instruments: gold-plated contacts • Treating infections: gold-laced solutions • Dentistry: bridges, crowns, and fillings
Decorative Arts • Buildings, artwork, glassware, and dinnerware

agency would require condemnation drilling and analysis to fully evaluate state mineral resources. The MDNRC also is concerned with surface activities that would affect all current and potential land uses on school trust land.

I.C.3 Bureau of Land Management's Responsibilities and Relationship to Planning

BLM has the responsibility and authority to manage the surface and subsurface resources on public lands. GSM's use of public land in the Headwaters Resource Area requires conformance with BLM's surface management regulations (43 Code of Federal Regulations [CFR], Subpart 3809), as well as various statutes, including NEPA, the Mining and Mineral Policy Act of 1970, and the Federal Land Policy and Management Act of 1976. BLM must review plans for development on BLM-administered land to ensure the following:

- The NEPA process is followed during the preparation of the EIS;
- Adequate provisions are included to prevent unnecessary or undue degradation of federal lands and to protect the non-mineral resources of the federal lands;
- Measures are included to provide for reclamation of disturbed areas;
- Conformance with the Headwaters Resource Area Management Plan is ensured; and
- Compliance with applicable substantive state and federal laws is achieved.

The BLM is acting as the agency lead on behalf of the MDEQ for purposes of Section 106 consultation with the State Historic Preservation Officer (SHPO). Thus, BLM is responsible for consulting with the SHPO in regard to: 1) the eligibility of cultural resources located on BLM, private, and state lands within and near the proposed project boundaries; 2) how those resources may be affected by the approval of the proposed project boundaries; and 3) identification of measures in which to mitigate effects. This consultation is coordinated with the MDEQ, GSM, the Confederated Salish-Kootenai Tribes of Montana, the Shoshone-Bannock Tribes of Idaho, and other interested parties as appropriate.

BLM's Headwaters Resource Area Resource Management Plan (RMP) was evaluated for constraints that have the potential to conflict with the Proposed Action. Management activities within the proposed project area are identified as livestock grazing, wildlife habitat, and recreation. Mineral resource development is in conformance with the RMP. Private lands have been included in the BLM's evaluation of the Proposed Action since operations on private lands in the project area may not occur if actions on federal lands are not authorized by the BLM.

BLM's NEPA Handbook (H-1790, Appendix 5) requires that all EISs address certain Critical Elements of the Human Environment. These critical elements are presented below along with the location in Chapters III and IV where the element is discussed. If the element does not occur within the Golden Sunlight Mine project area and would not be affected, this is indicated below, and the element is not discussed further in the EIS. This elimination of nonrelevant issues follows the Council on Environmental Quality guidelines as stated in 40 CFR 1500.4.

- Air quality - refer to Sections III.G and IV.G.
- Areas of Critical Environmental Concern - none would be affected.
- Cultural Resources - refer to Sections III.L and IV.L.
- Prime or Unique Farm Lands - none would be affected.
- Floodplains - none would be affected.
- Native American Religious Concerns - refer to Sections III.M and IV.M.
- Threatened or Endangered Species - refer to Sections III.F and IV.F.

- Solid or Hazardous Wastes - refer to Sections III.K and IV.K.
- Drinking Water/Groundwater Quality - refer to Sections III.B and IV.B.
- Wetlands/Riparian Zones - refer to Sections III.D and IV.D.
- Wild and Scenic Rivers - none would be affected.
- Wilderness - none would be affected.
- Environmental Justice - Environmental justice deals with the disproportionate impacts of federal actions on minority communities and low-income groups. As required by Executive Order 12898, this evaluation must consider social, cultural, economic, and human health effects and whether BLM's decision results in any inequity in the distribution of benefits or risks. The Golden Sunlight Mine Expansion Project was evaluated and no disproportionately high or adverse human health or environmental effects were identified for minority or low-income populations.

I.D ENVIRONMENTAL REVIEW PROCESS

Review of the application for continued mining and approval of operations is being conducted pursuant to the regulatory requirements contained in NEPA, MEPA, and the regulatory statutes identified above. The lead agency for preparation of the EIS is MDEQ, with BLM acting as co-lead. The U.S. Army Corps of Engineers (COE) and MDNRC are cooperating agencies. The United States Fish and Wildlife Service (USFWS), Montana Department of Fish, Wildlife, and Parks (MDFWP), the State Historic Preservation Office (SHPO), and Jefferson County were consulted during the preparation of this EIS.

A Notice of Intent (NOI) to prepare the EIS was published in the Federal Register on October 25, 1995. The NOI invited scoping comments to be sent to the MDEQ and BLM through November 10, 1995. On September 28, 1995, copies of a news release were issued to area newspapers, radio and television stations, and major interest groups. The MDEQ and BLM also mailed individual notifications to interested persons, agencies, or groups. A public meeting was held in Whitehall, Montana, on October 17, 1995. Approximately 75 to 100 members of the public attended the meeting, and comments were recorded. As a result of the public scoping process, 15 comment letters were received by the MDEQ and BLM. Issues and concerns raised at the meeting and contained in the written comments were summarized for consideration in preparation of the Draft EIS.

In accordance with their regulatory and land management authority, the agencies will review the Proposed Action submitted by Golden Sunlight Mine, Inc. and decide whether to approve it, disapprove it, or approve it with modifications, as described in the alternatives and Mitigation Measures contained in this EIS and any others developed by the agencies. Implementation of the Proposed Action or alternatives also is contingent upon approvals, permits, etc. required by other agencies, including the COE and MDNRC. The MDNRC Trust Land Management Division would require review of the proposal, and acquisition of licenses, leases, etc. and approval of activity on state school trust surface and/or mineral estate prior to any disturbance on these lands. The permits necessary from MDNRC would depend on the type of disturbance proposed. For permanent disturbances, condemnation work, compensation, and/or a land exchange would be necessary. Additional MEPA review relative to state trust lands would be required prior to MDNRC trust lands decisions. MDNRC intends to use this EIS and the data it provides as a baseline for this review.

I.E APPLICABLE REGULATORY REQUIREMENTS AND COORDINATION

Table I-3 lists the permits, licenses, and reviews that are required prior to approval of the proposed amendment. The air quality permit would not require modification because the mining and milling rates would not change. Consultation with the Montana SHPO regarding cultural resources has been initiated by BLM. GSM's Stormwater Pollution Prevention Plan has been approved by MDEQ, with required updating, as necessary. GSM has submitted a Predischarge Notification (PDN) for Nationwide Permit 26 to the COE for future fills affecting jurisdictional waters of the U.S.; past fills are being permitted separately from the PDN by the COE. Jefferson County has been consulted regarding emergency planning and weed control.

I.F ORGANIZATION OF THE ENVIRONMENTAL IMPACT STATEMENT

This EIS follows the Council on Environmental Quality's recommended organization (40 CFR § 1502.8): Chapter I provides descriptions of existing and historical operations, the purpose and need of the Proposed Action, the role of the MDEQ and BLM, and public participation in the EIS process; Chapter II describes the Proposed Action and alternatives; Chapter III describes the affected environment; and Chapter IV describes direct, indirect, and cumulative impacts associated with the Proposed Action and alternatives and possible mitigation to reduce or minimize impacts. Chapter V summarizes the consultation and coordination for preparation of the Draft EIS. Chapter VI presents the list of preparers, and Chapter VII is a list of references. Copies of supporting documents are on file in MDEQ's office in Helena, Montana, and at BLM's offices in Butte, Montana.

Table I-3

Mine Permits, Licenses, and Reviews

Granting Agency	Permit/Approval
USDI Bureau of Land Management, Butte District	Approval of Plan of Operations.
U.S. Army Corps of Engineers (COE)	Section 404 Permit under the Clean Water Act for dredge, fill, and excavation of waters of the U.S.
U.S. Fish & Wildlife Service	Review under the Endangered Species Act.
Environmental Protection Agency (EPA)	Review under the Clean Air Act and Clean Water Act.
Montana Department of Environmental Quality (MDEQ)	Administering MMRA and MEPA; issuing Operating Permit (No. 00065 for GSM); requiring bonding for reclamation of disturbed lands; ensuring compliance with state water, air, and hazardous waste regulations; and issuing water discharge and air quality permits.
Montana Department of Natural Resources and Conservation (MDNRC)	
Trust Land Management Division:	Approval of activities on state trust surface and mineral estate (subsurface) lands; issuing land use licenses, easements, and mineral leases; conducting land exchanges.
Water Resources Division, Water Rights Bureau:	Permit to allow beneficial use of State of Montana water through surface water diversion or groundwater withdrawal.
State Historic Preservation Office (SHPO)	Review under the National Historic Preservation Act and 36 CFR 800 regarding protection of cultural/historic resources.
Montana District Court Decision -- Oversight Committee Review	Decision of September 1, 1994, indicated (among other matters) that an EIS is required for Amendment 008 of Operating Permit 00065. The Oversight Committee will review preparation of the EIS.
Jefferson County Disaster & Emergency Relief Coordinator	Review of Floodplain and Emergency Operations Plans regarding uncontrolled releases of hazardous substances.
Jefferson County Weed District	Review for control and prevention of noxious weed infestations.

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Alternatives Including The Proposed [illegible]

Process Used to Formulate Alternatives [illegible]

Alternatives Analyzed in Detail [illegible]

Alternatives Evaluated but Eliminated from Detailed Analysis 105

Summary Comparison of Impacts Among the Proposed Action and Alternatives 107

Agency-Preferred Alternative 110

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II ALTERNATIVES INCLUDING THE PROPOSED ACTION

This chapter presents the process used to formulate the alternatives evaluated in this EIS, descriptions of alternatives analyzed in detail, and general descriptions of alternatives eliminated from detailed analysis. This chapter also provides a summary comparison of the environmental impacts associated with each alternative analyzed in detail in Chapter IV, and identifies the agency-preferred alternative.

II.A PROCESS USED TO FORMULATE ALTERNATIVES

The two primary alternatives evaluated in this EIS were prompted by the litigation and District Court Order described in Chapter I and GSM's proposal to continue mining beyond the *Interim Dump Plan*. Under the No Action Alternative, mining activities will stop after the completion of the *Interim Dump Plan*, and all mine facilities will be reclaimed using the reclamation plan that has been modified and approved by MDEQ and BLM to satisfy each agency's statutory mandate and the Montana District Court Order. GSM's proposal to continue mining beyond the *Interim Dump Plan* has been presented and evaluated as the Proposed Action. It includes a slightly different reclamation plan and an extended reclamation schedule.

Nine secondary alternatives were formulated during the preparation of this EIS. Five of these alternatives were developed to minimize specific environmental impacts associated with the Proposed Action. The remaining four alternatives were developed to address reclamation issues raised in the Court Order and Settlement Agreement, regardless of whether the agencies select the No Action Alternative or the Proposed Action. In total, 15 alternatives, including the No Action Alternative and the Proposed Action, were evaluated. Seven of these 15 alternatives are analyzed in detail for this EIS.

An alternative was analyzed in detail if preliminary analyses indicated that: 1) the alternative was likely to reduce a specific significant environmental impact associated with continued mining or would increase the likelihood of reclamation success; 2) the alternative would meet or exceed MDEQ and BLM regulatory requirements and Montana Constitutional requirements; 3) implementing the alternative would not be likely to create additional, off-setting negative environmental impacts; and 4) implementing the alternative would be economically and technologically feasible. Alternatives were eliminated from detailed analysis if they could not satisfy these four criteria. Section II.B presents the alternatives analyzed in detail, and Section II.C presents alternatives evaluated but eliminated from detailed analysis. All are discussed further in this chapter. An outline for the chapter is provided below.

II.B ALTERNATIVES ANALYZED IN DETAIL

Primary Alternatives:

II.B.1 Discontinued Mining After the *Interim Dump Plan* (No Action Alternative)

II.B.2 Continued Mining Beyond the *Interim Dump Plan* (Proposed Action)

Secondary Alternatives Associated with the Proposed Action

II.B.3 Continued Mining with a Permanent Diversion Structure Routing Sheep Rock Creek Around the East Waste Rock Dump (Return Diversion Alternative)

II.B.4 Continued Mining with a Divided East Waste Rock Dump, Leaving Sheep Rock Creek in its Original Channel (Divided Dump Alternative)

Reclamation Alternatives Applicable to Either the No Action Alternative or the Proposed Action

II.B.5 Reclamation Requiring Reduced 3:1 Waste Rock Dump Slopes (3:1 Slope Alternative)

II.B.6 Reclamation Requiring Measures to Prevent Surface Water from Collecting in the Pit (No Pit Pond Alternative)

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II.B.7 Reclamation Requiring Partially Backfilling the Pit (Partial Backfill Alternative)

II.C ALTERNATIVES EVALUATED BUT ELIMINATED FROM DETAILED ANALYSIS

Secondary Alternatives Associated with the Proposed Action

II.C.1 Continued Mining with a Permanent Overdrain for Sheep Rock Creek (Overdrain Alternative)

II.C.2 Continued Mining with Measures to Destruct Cyanide in the Tailings Impoundments to Prevent Wildlife Exposure to Toxic Levels of Cyanide During Mine Operations (Cyanide Neutralization Alternative)

II.C.3 Continued Mining with Measures to Neutralize Acid in the Tailings Impoundments to Prevent Long-Term Acid Rock Drainage (Acid Neutralization Alternative)

Reclamation Alternatives Applicable to Either the No Action Alternative or the Proposed Action

II.C.4 Reclamation Requiring Backfilling the Pit to Pre-Mining Contour, Replacing Soil, and Revegetating (Complete Backfill Alternative)

When selecting an alternative to implement, the agencies will choose between the two primary alternatives (the No Action Alternative and Proposed Action). These alternatives can stand alone, or the agencies can add one or more of the secondary alternatives that were analyzed in detail. For example, the agencies could select the No Action Alternative as the primary alternative and additionally require the 3:1 Slope Alternative. Or the agencies might select the Proposed Action but modify it to include the Return Diversion and No Pit Pond Alternatives. The agencies analyzed the secondary alternatives in this EIS assuming the disturbances associated with the Proposed Action as "worst-case scenarios."

2.8 ALTERNATIVES ANALYZED IN DETAIL

2.8.1 Discontinued Mining After the Interim Dump Plan (No Action Alternative)

Under the No Action Alternative, mining will cease when the waste rock dump space provided for in the *Interim Dump Plan* is filled. No new construction or expansion of the pit, waste rock dumps, process facilities, or tailings impoundments will occur. Current mining operations will cease, and all facilities will be reclaimed using the existing reclamation plan approved under the *Interim Dump Plan*. Current mining operations and the existing reclamation plan are described in detail below.

2.8.1.a Current Mining Operations

The mine permit boundary encompasses approximately 5,071 acres, including 3,792 acres of GSM-owned land, 1,219 acres of BLM-administered land, and 60 acres of state school trust land. The surface disturbance area for mine facilities through the *Interim Dump Plan* encompasses approximately 2,336 acres, including 1,723 acres of GSM-owned land and 613 acres of BLM-administered land. Table II-1 shows surface ownership of the permit boundary and the disturbance area, by mine facility, through the *Interim Dump Plan*. A total of 257 acres of disturbance will occur over state school trust subsurface lands (see Table II-2), with 148 acres of sulfide-covered disturbance, and 110 acres of non-sulfide covered disturbance.

Mining operations at the mine site are conducted with conventional open-pit methods utilizing drilling, blasting, loading, and hauling. Figure II-1 presents a general flow diagram describing current mining activities. The locations of existing permitted facilities at the mine site, including the pit, plant site, tailings impoundments, and waste rock dumps, are shown on Map I-2. Approximately 60,000 to 70,000 tons of rock are excavated from the pit per day, totaling 22 million tons per year. Only a portion of this rock (approximately 2.5 million tons per year) is ore; the remainder is classified as waste rock and stored in designated waste rock dumps. Ore is hauled to the plant site for processing. Approximately 24.1 million tons of ore will be processed through the completion of the *Interim Dump Plan*.

Drill equipment consists of eight mobile rotary drill rigs. Benches within the pit are 25 feet high within ore zones. Benches are 50 feet high in waste rock stripping areas. Grade control is based on blast-hole assays which are used to classify material and plan ore processing. After blasting, broken material is loaded with 9 and 17-cubic-yard electric shovels or 7.5 and 13.5-cubic-yard front end loaders. The material is hauled in mechanical/electric drive haul trucks. The fleet consists of 50-ton, 75-ton, 120-ton, and 170-ton capacity haul trucks. Other mining equipment includes dozers, motor graders, water and sand trucks, and several light-duty vehicles.

Ore and waste rock mining occurs during two 12-hour shifts per day, 7 days per week. The work force at the mine averaged approximately 285 employees between 1991 and 1998. Layoffs in August of 1998 reduced the work force to 205 employees, from a high of 301 employees in 1995.

Waste Rock Dumps and Buttress

Waste rock is extracted from pit benches and hauled to dump complexes located to the east and west of the pit. Waste rock also is hauled to the buttress located southeast of the plant site (see Map I-2). Waste rock production rates have ranged from approximately 0.50 to 34.3 million tons per year. Approximately 319 million tons of waste rock will be deposited in the waste rock dumps and buttress through the *Interim Dump Plan*.

Waste rock dumps are constructed by end-dumping material from haul trucks. Prior to reclamation, dump slopes are at the natural angle of repose for the material (1.4:1, or slopes of about 36 degrees from horizontal). Waste rock dump tops are dressed with dozers to create relatively smooth, level surfaces with

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Table II-1

Surface Ownership of Disturbance and Permit Boundary Area Under the No Action Alternative (Acres)

Facility/Area	GSM	BLM	State of Montana	TOTAL
PERMIT BOUNDARY AREA:	*3,792*	*1,219*	*60*	***5,071***
DISTURBANCE AREA:				
West Waste Rock Dump	138	476	0	**616**
East Waste Rock Dump	263	76	0	**339**
Buttress	166	3	0	**169**
Tailings Area	769	2	0	**771**
Pit	275	37	0	**312**
Plantsite Area	81	17	0	**98**
Roads Outside Disturbance Boundary	31	0	0	**31**
TOTAL DISTURBANCE AREA	**1,723**	**613**	**0**	**2,336**

Note: Totals may not add due to rounding.

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Table II-2

Disturbance Occurring Above State School Trust Subsurface Lands
No Action Alternative

Mine Facility	State School Trust Subsurface Section Affected	Surface Disturbance (Acres)	Sulfide Covered (Acres)	Non-Sulfide Covered (Acres)
East Waste Rock Dump				
Dump and Haul Roads	S17, S20	170	170	0
Miscellaneous Disturbance	S20	9	0	9
Buttress				
Miscellaneous Disturbance	S20	14	0	14
Tailings Area				
Tailings	S28, S33	78	78	0
Seeded Area	S28, S33	6	0	6
Miscellaneous Disturbance	S28, S33	81	0	81
TOTAL		357	248	110

Note: Totals may not add due to rounding.

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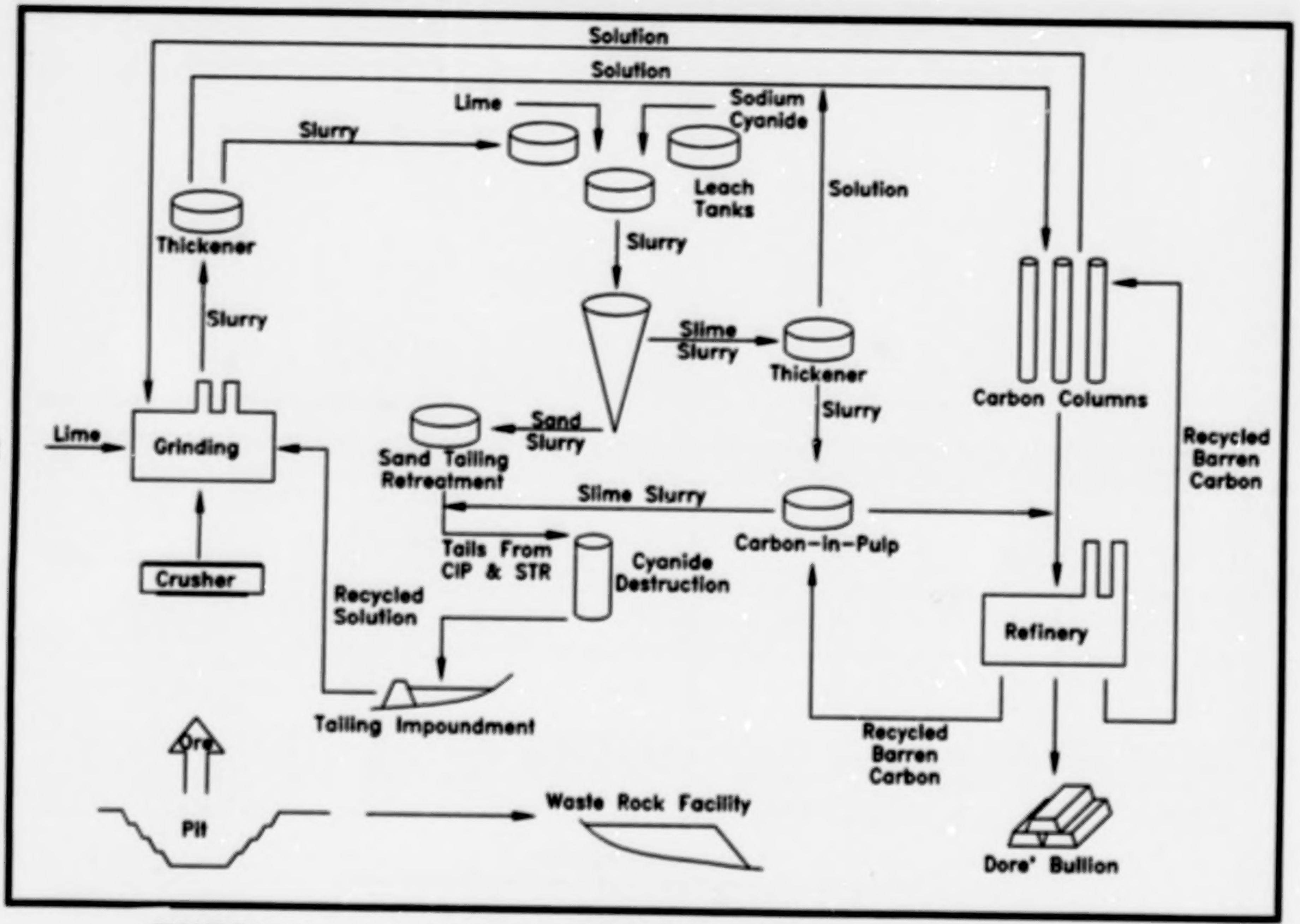

FIGURE II-1 SCHEMATIC OF ORE PROCESSING OPERATIONS - GOLDEN SUNLIGHT MINES

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safety berms at dumping points. Operationally, the waste rock dump tops are graded to limit runoff from adjacent areas and to prevent significant accumulations of runoff water that could produce seeps of acid water below the dumps. Also, most waste rock dumps are constructed with vertical benches that will provide slope length breaks to help control erosion off the waste rock dump from major storm events after the slopes are reclaimed. Limited erosion occurs from waste rock dump slopes during operations because of the coarse nature of the materials. Retention berms are constructed around the expanding dump toe after soil stripping. The berms are designed to:

- Prevent precipitation that falls on the disturbed waste rock dumps from running-off the stripped-soil surface at the dump toes and causing erosion;
- Promote infiltration of surface water run-off at the toe of the dumps; and
- Prevent waste rock from rolling beyond the disturbed area.

Dump designs, retention berms, and surface water diversion structures are described in the Operating Permit (GSM 1995a, Appendix 6 and 7). Dump slope reclamation is discussed in Section II.B.1.b, Existing Reclamation Plan.

The buttress was designed to help stabilize ground movement. It is constructed as a series of benches from which waste rock can be end-dumped to create 3:1 slopes for reclamation. Bench tops are dressed with dozers to create relatively smooth, level surfaces with safety berms at dumping points. Retention berms also are constructed around the expanding buttress after soil stripping to prevent surface run-off erosion, promote infiltration, and to prevent waste rock from rolling beyond the disturbed area. The buttress design is described in *Stability Analysis, 1995 Interim East Buttress Extension* (Golder Associates Ltd. 1995h). Buttress reclamation is discussed in Section II.B.1.b, Existing Reclamation Plan.

Ore Processing

Coarse ore is crushed and ground to a fine slurry before the gold can be extracted. Crushing involves reducing rock particle size to approximately 5/8 inch using gyratory and cone crushers. Wet grinding in rod and ball mills further reduces rock size to less than 0.01 inch, forming an ore slurry.

The gold is extracted from the ore slurry using a vat cyanide process. The ore slurry is mixed with sodium cyanide, lime, and compressed air in twelve 400,000-gallon leach tanks equipped with agitators to keep the solids in suspension. The leaching process places gold into solution as a gold-cyanide compound. Gold is separated from the solids by washing in hydrocyclones to separate the slime and sand fractions of the leach tailings. The sand fraction goes to the Sand Tailings Retreatment (STR) circuit.

The STR circuit separates the gold-bearing sulfides from the sand portion of the tailings by gravity concentration in spiral-shaped launders. The pyrite-rich concentrate is ground in a ball mill to 0.002 inch in size to expose gold encapsulated in pyrite to further cyanide leaching. Following preliminary leaching, the resulting gold-bearing solution and the finely-ground pyrite are sent to the activated carbon circuits for recovery of the dissolved gold. The remaining pyrite-rich material is diverted to the tailings stream for disposal in the tailings impoundments.

The slime fraction from the washing circuit is sent to a thickener, which produces two product streams: a clear overflow stream; and an underflow stream, which contains all of the slime solids. Both streams are then treated by carbon adsorption for gold recovery. Gold adsorption occurs in carbon-in-pulp tanks, and carbon columns charged with activated carbon from coconut shells.

Gold is removed from the carbon in pressure stripping vessels. Gold removed from the carbon is returned to solution for electrowinning onto steel wool cathodes. The gold-laden steel wool is smelted and poured into bars, which assay about 70 percent gold, 20 percent silver, and 10 percent other metal impurities.

INCO SO_2/Air Cyanide Destruction Process

Beginning late 1997, GSM will operate an INCO SO_2/Air circuit to destroy cyanide in the tailings materials prior to sending them to the tailings disposal facility. The process is designed to reduce the hazards to wildlife and reduce the risks of groundwater contamination associated with cyanide in the tailings impoundments.

Tailings slurry will be pumped from the existing final tailings box to a new wash thickener where overflow solution will be recycled for reuse in the plant, and underflow will be pumped to a reaction vessel. The reaction vessel will be a modified leach tank. The INCO SO_2/Air cyanide destruction process will oxidize cyanide (CN^-) to form cyanate (OCN^-). It will use a mixture of SO_2 and O_2 as the oxidizing agent in the presence of soluble copper which will act as a catalyst. Metals released from the cyanide compounds will be precipitated as metal hydroxides. Lime will be both present in the feed and added during the process to control pH.

The only new reagent at Golden Sunlight Mine that will be required is SO_2. Lime for the process will come from the existing wet lime distribution system. Additional equipment required includes the leach tank, liquid SO_2 storage and metering equipment, a tank agitator, air compressors, and a building to house the facilities. Electrical power consumed by the process will require addition of transformer capacity at the mine.

The INCO cyanide destruction process can be designed to treat feeds with weak acid dissociable cyanide (WAD CN) concentrations of several hundred parts per million (ppm) to produce effluents with cyanide concentrations as low as 1 ppm. At Golden Sunlight Mine, the INCO process will be used as necessary to limit cyanide concentrations in the tailings impoundment supernatant pond to minimize the hazard of the pond to wildlife. Cyanide concentrations will be kept low enough to prevent wildlife mortalities. A concentration of less than 50 ppm WAD CN is expected to be adequate. Testing on slurries at Golden Sunlight Mine has shown that effluent WAD CN concentrations below 5 ppm are achievable. It is likely that concentrations of at least 30 ppm or below will be achieved.

Construction of the system was scheduled to be completed in late 1997, with start-up proceeding immediately thereafter. The supernatant pond is expected to achieve concentration levels considered safe for wildlife approximately 6 months to a year following start-up (early to mid-1998).

Tailings Impoundments

After ore processing, mill tailings are piped as a slurry mixture to the tailings impoundments shown on Map I-2. Tailings Impoundment No. 1 occupies approximately 144 acres; Tailings Impoundment No. 2 occupies approximately 199 acres. As of December 31, 1995, a total of 29.0 million tons of tailings had been deposited in the two impoundments. Tailings were deposited in Tailings Impoundment No. 1 from 1982 until construction of Impoundment No. 2 was completed in 1993. Reclamation of Impoundment No. 1 began at this time. Approximately 26.3 million tons of tailings have been deposited in Impoundment No. 1, and approximately 2.7 million tons in Impoundment No. 2. Tailings Impoundment No. 2 has a design capacity which will hold approximately 35 million tons of tailings. As of December 31, 1995, the remaining permitted capacity of Impoundment No. 2 was approximately 27.3 million tons of tailings.

Tailings slurry is currently approximately 50 percent solids by weight. The tailings solution currently has a pH of 11 and contains less than 1 pound of cyanide per ton. The slurry is delivered to the impoundment via a 12-inch diameter, HDPE pipeline; this system has been in place since 1983. The pipeline that supplied Tailings Impoundment No. 1 is a single-wall HDPE surface pipeline. The single-wall pipeline will be replaced by a dual-contained pipeline during 1997. The old tailings line and route will be reclaimed during 1997 after testing of the new pipeline. The

INCO cyanide destruction process will be implemented in 1997. The circuit will destroy cyanide in the tailings prior to sending them to the impoundments, and will reduce cyanide in the tailings to at least 30 ppm or below.

At the impoundment, the slurry is gravity-fed through a 26-inch hydro-cyclone to separate the coarse sand fraction from the finer slime fraction. The sand fraction constitutes approximately 22 percent of the total tailings solid volume, and is used to build up the central portion of the dam. The slime fraction is deposited inside the tailings impoundment structure. After the solids have settled, the water is pumped back to the mill and reused in the milling process.

Both tailings impoundment designs use centerline construction techniques where initial construction includes a toe dike and a starter embankment using compacted, homogeneous, granular fill. The fill was taken from borrow areas within the permit boundary or from the floor of the impoundments. Cycloned sands are used to continuously raise the embankment crest and extend the downstream toe from the starter embankment. Wing dike extensions are constructed in stages using borrow material.

Tailings Impoundment No. 1 is an unlined impoundment, and relies on a slurry cut-off wall and pumpback wells to control leakage. A 60-mil HDPE synthetic liner was placed over a prepared surface in Tailings Impoundment No. 2. The liner covers the impoundment basin and extends beneath the starter embankment, toe dike, and seepage/reclaim basins. A 2- to 3-foot layer of cycloned sands was placed to cover the synthetic liner beneath the starter embankment and the toe dike for protection of the liner during construction. Drains were constructed above the liner throughout the Tailings Impoundment No. 2 basin for dewatering purposes. The drains connect to seepage/reclaim basins downgradient from the embankment.

The reclaimed water reporting to the seepage basins is pumped back to the ore processing facilities or back to Tailings Impoundment No. 2. The seepage basins have 24 to 48 hours of storage volume. Portable diesel pumps are available for emergency response. In addition, two lined overflow basins provide 40-million gallons of emergency capacity.

Ancillary Mining Facilities

Aside from crushing and ore processing facilities at the plant site, ancillary facilities that support mining include an administration building (office), a safety building, mining and equipment maintenance shops, an assay and metallurgical laboratory, fueling facilities, an explosives storage area, a blasting contractor shop and office, core logging and storage buildings, a solid waste landfill, a septic system, and an employee parking lot.

The entire mine site is fenced with a five-wire barbed fence with locked access in all areas and is patrolled by security personnel 24 hours a day, 7 days a week. The plant site is accessed by an access road leading north from Montana Highway 2 (see Map I-2). Traffic along the mine site access road includes mine employees, vendors, contractors, and visitors. Mine-related vehicles within the project boundary include haul trucks, loaders, drilling equipment, pickup trucks, maintenance trucks, and mine busses.

The plant site is serviced by a septic system and drain field located east of the warehouse in the plant area. The crusher, blasting contractor building, and drill core shed are serviced by their own septic systems and drain fields. Certain types of non-hazardous solid waste are deposited in solid waste landfills located on-site within waste rock dumps. The location of disposal sites varies within the waste rock complex, depending upon operational considerations. The landfills were permitted as part of the mining operation, as allowed under MCA 75-10-214.

Wastes generated at the mine that are not disposed of on-site include: greases and oils; washing sludges or solvents; batteries; full or partially-full paint containers; full or partially-full barrels; undrained oil filters; used assay lab slag, crucibles and cupels; and full or partially full chemical containers. Descriptions of storage, handling, disposal, and recycling methods for these and other hazardous materials are given below.

Hazardous Materials Management

In compliance with Section 313, Title II of the Superfund Amendments and Reauthorization Act of 1986 and the Pollution Prevention Act of 1990, GSM currently reports the storage and use of specific chemicals to the Environmental Protection Agency (EPA). The Resource Conservation and Recovery Act (RCRA) database lists facilities that report hazardous substances over certain threshold quantities. The RCRA list includes hazardous waste treatment, storage, and disposal (TSD) facilities, hazardous waste generators, or hazardous waste transporters.

The mine site is listed in the RCRA database as a small-quantity generator of hazardous waste (EPA Identification Number MTD000710210). Designation as a small-quantity generator indicates a facility generates less than 1,000 kg/month (2,205 lbs/month) of non-acutely hazardous waste, or less than 1 kg/month (2.205 lbs/month) of acutely hazardous waste. Mining operations at the project site currently produce approximately 442 kg/month (975 lbs/month) of hazardous waste, primarily in the form of lead (assay lab slag, crucibles, and cupels contain small concentrations of lead).

The mining facility may accumulate hazardous waste for up to 90 days in storage areas or temporary accumulation areas (TAAs). The facility does not treat, store for more than 90 days, or dispose of hazardous wastes on-site. A list of hazardous wastes generated at the mine site is provided in Table II-3. Hazardous wastes generated at the mine are disposed of off-site by a licensed contractor.

The term "hazardous materials" is defined in 49 CFR 172.101; "hazardous substances" are defined in 40 CFR 302.4 and the Superfund Amendments and Reauthorization Act (SARA) Title III. Hazardous materials and hazardous substances that are transported, stored, or used on-site in quantities greater than the Threshold Planning Quantity (TPQ) designated by SARA Title III for emergency planning, are summarized in Table II-4.

Small quantities of hazardous materials not included in Table II-4 are used at the mine site. These materials are contained in commercially produced paints, office products, and automotive and equipment maintenance products.

The number of shipments of hazardous materials and hazardous waste transported to and from the mine site per week under the No Action Alternative is provided in Table II-5. Hazardous materials are transported to the mine site by U.S. Department of Transportation (DOT)-regulated transporters and stored on-site in DOT-approved containers. Secondary spill containment structures are provided for storage containers. All hazardous materials are stored on private land.

Spill Prevention, Containment, and Release Reporting

GSM's existing Spill Contingency Plan for existing operations (GSM no date) delineates a Plan of Action for spills and provides information on chemicals used at the site, as well as Material Safety Data Sheets (MSDS).

A synthetically lined containment area is currently installed around the main leach tanks at the mine plant site. This containment is designed to hold 110 percent of one tank volume. The pyrite leach tank containment system has been completely reconstructed, increasing the containment volume and adding an HDPE liner to minimize the potential for leaks.

The existing contingency plan provides for draining mill process solutions into the tailings impoundments if detoxification of mill process streams is necessary. Any spills and leaks at the processing facility plant site are contained and routed directly to the tailings lines. Floor sump pumps in the mill have the capacity to pump approximately 1,370 gpm in the event of a spill. In addition, floor drains have been installed at the mill to handle any spills that

Table 8-3

Hazardous Waste Generated at the Mine Site

Substance	Rate of Generation	Hazardous Waste Characterization	Concentration (ppm)	Amount Stored (typical)	Storage Method	Waste Management
Lab cupels	4,500 lbs/year	Lead (Pb)	4,000-5,000	2,000 lbs.	Metal container	Recycled at Asarco Smelter
Lab crucibles	2,300 lbs/year	Lead (Pb)	180	800-1,500 lbs.	DOT-approved barrels with secondary containment	Shipped to hazardous waste disposal site
Lab slag	4,600 lbs/year	Lead (Pb)	3,200	1,000-2,000 lbs.	DOT-approved barrels with secondary containment	Shipped to hazardous waste disposal site
Hot water parts washer sludge	10-20 gallons/ year	Lead (Pb) Cadmium(Cd) Arsenic (As) Chromium (Cr)	194 17 62 98	10-20 gal.	DOT-approved barrels with secondary containment	Shipped to hazardous waste disposal site

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Table 8-4

Hazardous Materials Management at the Mine Site

[illegible]	Annual Use	TPQ[1] (pounds)	Use	Amount Stored (typical)	Storage Method	[illegible]
Sodium Cyanide	3.8 million pounds per year	100	Gold recovery process	73,000 gallons maximum storage; 37,000 gallons stored on average.	Above-ground bulk tanks; solids	Portions are recycled or neutralized and left in place. The majority of the cyanide remains in the tailings, degrading naturally over time.
Diesel fuel	1.8 million gallons per year	10,000	Equipment fuel	18,000 gallons	Above-ground bulk tanks	No Waste (consumed on site)
Gasoline	80,000 gallons per year	10,000	Equipment fuel	3,000 gallons	Above-ground bulk tanks	No Waste (consumed on site)
Hydrochloric Acid	31,000 gallons per year	5,000	Gold recovery process	5,000 gallons	Above-ground bulk tanks	No Waste (consumed on site)
Sodium Hydroxide	381,000 pounds per year	1,000	Gold recovery process	90,000 pounds	Above-ground bulk tanks	No Waste (consumed on site)
Hydrogen Peroxide	80,000 pounds per year	1,000	Cyanide destruction	40,000 pounds	Above-ground bulk tanks	No Waste (consumed on site)
Sulphur Dioxide[2]	1,644 tons per year	500	Cyanide destruction	28 tons average; 45 tons maximum capacity	Stored in liquid form in a carbon steel tank padded with dry air	No Waste (consumed on site)

[1] TPQ = extremely hazardous substance threshold planning quantity designated by SARA, Title III.

[2] Sulphur Dioxide will be utilized in the INCO SO_2/Air cyanide destruction process; construction of the system is scheduled to begin in April 1997 and be completed in August 1997.

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Table II-6

Hazardous Material and Hazardous Waste Traffic Along the Mine Site's Access Road

Vehicle Types	Round-Trips along Access Road ([illegible] miles long)
Cyanide Shipments	11-14/month
Diesel Fuel Shipments	15/month
Gasoline Shipments	1/month
Hydrochloric Acid Shipments	1/month
Sodium Hydroxide	1/month
Hazardous Waste Shipments	2-4/month
Sulphur Dioxide Shipments	5/month
Total	377-[illegible]/year

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might exceed the existing floor sump pump capacities. The buried portion of the tailings line has been replaced with a dual contained pipe at twice the previous slope to increase the flow rate.

Drums of a cyanide neutralization chemical (calcium hypochlorite) are on hand to detoxify any spills or leaks that might escape the containment systems. After detoxifying, the spilled material and impacted ground are removed to the tailings impoundments. The mine has an on-site cyanide analyzer capable of measuring low levels of cyanide. Samples of the cleanup area are analyzed to ensure that all of the impacted ground and spilled materials have been removed. Duplicate samples are sent to outside laboratories for confirmation. Spills or leaks along the tailings line route would be handled in a similar fashion.

Equipment for storage and use of hydrogen peroxide is kept on-site for detoxification of the tailings impoundments. Tailings impoundment monitoring wells are monitored in accordance with the agency-approved plan and the information is reported to MDEQ and BLM on an annual basis. Tailings impoundment pumpback wells associated with Tailings Impoundment No. 1 are designed to discharge into Tailings Impoundment No. 2 during mine life, and into the permanent water treatment plant thereafter. Tailings Impoundment No. 2 seepage is collected in the reclaim ponds and will eventually be pumped to the permanent water treatment plant for treatment.

Energy Demand and Supply

The electric power for mining facilities is currently provided by the Montana Power Company via a 17.5-kilovolt (kV) transmission line that links the plant site with a substation located south of the project boundary (see Map I-2). Several smaller 4.16-kV distribution lines extend from the plant site to the tailings impoundments and pit. A new 4.16-kV distribution line will be required to transmit power to the permanent water treatment plant that will be built to treat pit outflow, tailings seepage and waste rock seepage at mine closure (see Section II.B.1.b, Existing Reclamation Plan). The new distribution line will parallel the access road for the permanent water treatment plant.

Small portable generators are used for emergency lighting for the various facilities. A natural gas pipeline extends along the main access road to the plant site and supplies gas to the mill, maintenance shops, and assay laboratory. Natural gas is used to fuel heaters, the air scrubber, crusher, boiler, reactivation kiln, and refining furnaces.

Machinery, including trucks, drills, and excavation equipment, is powered by gasoline and diesel fuel. Fuel is stored in a new above-ground fuel bay located on the East Waste Rock Dump Complex north of the plant site (see Map I-2). The facility includes two 45,000-gallon aboveground storage tanks for diesel. These tanks are set in a cement structure that provides secondary containment.

Water Demand and Supply

Approximately 1,119 gpm of water is required for ore processing, dust suppression, and drinking water. An average of 167 gpm of fresh water is pumped from the Jefferson Slough. In addition, approximately 30 gpm of groundwater is intermittently pumped from a well located on the southwest side of the project area. Water from the well is used primarily for dust control. The remainder of the water requirements (approximately 922 gpm) are met by water pumped from the tailings impoundments and pit that is recycled for ore processing at the plant site. A small pit dewatering pond exists below the ore crushing area.

Potable water at the plant site is currently provided in portable containers supplied by a local vendor and by a potable water treatment facility at the mine site. Water resources and water rights at the mine site are described in Chapter III of this document.

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Water Drainage and Surface Water Management

GSM's *Storm Water Pollution Prevention Plan* for existing mining operations was revised in August 1995 (GSM 1995b). Water that accumulates in the excavated pit bottom during mining operations is treated with lime and pumped to the mill for use in ore processing. Diversion channels route surface water runoff around the tailings impoundments and waste rock dumps. Diversion channels that do not return to natural drainages but release water onto natural undisturbed slopes are designed with rip-rap diffusion structures to receive the flow and disperse it on the hillside. Sediment control berms are constructed at the confluence of diversion channels with natural channels. Sediment control berms consist of rip-rap aprons which allow water to pass but inhibit transport of sediment from a channel to the natural slope. Rip-rap berms are placed across the apron every 25 to 40 feet to dissipate energy. These structures are intended to reduce sediment delivery to natural channels before and during the period when reclamation is taking place. After reclamation is complete and vegetation is reestablished, trapped sediment will be removed from the upstream sides of the berms and stockpiled or revegetated and stabilized in place.

Pit Water. Pit water is a combination of groundwater seepage and surface water runoff that flows into the excavated pit. Pit water is collected in sumps at the bottom of the open pit and is pumped to a lime-treatment facility in the plant where it is treated for use in ore processing. At mine closure, pit water will be routed to a permanent water treatment facility created to treat pit water after ore production ceases. GSM monitors pit inflows and pumping rates on a monthly basis, and reports this information to MDEQ and BLM on an annual basis. At least once every 5 years GSM revises its bond calculations and submits additional bonding for the construction and operation of the permanent water treatment plant. Construction of the permanent water treatment plant to treat pit outflow at mine closure is required by Stipulation 20 to Amendment 008 approval in 1990 (see Section I.B.1, Stipulation Compliance).

Approximately 37 gpm is currently pumped from the pit to the lime-treatment facility, based on 1996 data. An analysis of the sludge produced from the water treatment process indicates that it is not a hazardous waste under RCRA, and can be deposited along with tailings in the tailings impoundments (GSM 1995b).

A hydrologic model has been completed by GSM to estimate the amount of water that will be introduced to the pit from both groundwater inflow and precipitation should the mine cease operations after the *Interim Dump Plan* in 1997 (see Section II.B.1.b, Existing Reclamation Plan).

Tailings Impoundments. Two diversion channels around the tailings impoundments, referred to as the east and west diversion channels, have been designed to route storm water flow around both impoundments. The east diversion channel has already been constructed, whereas the west diversion channel has been redesigned and is being constructed in 1996 and 1997. The east diversion channels were sized as required by Amendment 008, Stipulation No. 17. Because of uncertainties in the wording of the stipulation, the east diversion is sized for the full Probable Maximum Flood (PMF) based on a 6-hour storm. A clarification of the stipulation by MDEQ in May 1995 has allowed GSM to redesign the west diversion to accommodate half the PMF based on a 6-hour storm.

Waste Rock Dumps. Runoff from waste rock dumps is collected in storm water diversion channels. Two types of diversion channels are built on waste rock dumps: low gradient channels which collect runoff on terraces, and high gradient channels which bring the collected runoff down the dump to natural channels. The steeper grades on the latter channels require rip-rap. The dump-related diversions are sized for the 100-year, 1-hour precipitation event which is anticipated to yield the highest peak flows for a 100-year recurrence interval event. This design was presented to

MDEQ for the *Interim Dump Plan* and approved in 1995.

Emergency and Contingency Plans

Emergency planning and response measures for process solutions are discussed in the Hazardous Materials Management section above. Emergency planning and response measures for ground movement, fire, and medical emergencies are discussed below.

Ground Stability Monitoring and Reporting. Geodetic monitoring data for ground movement are currently reported to MDEQ and BLM on a monthly basis. Geodetic surveys of three points are conducted weekly to detect movement as early as possible. Monthly surveys of 12 geodetic points are completed in addition to the three points surveyed weekly.

GSM also monitors inclinometers and piezometers. Inclinometers are surveyed on a rotating basis to detect any ground movement, such that some inclinometers are surveyed each week. Individual inclinometers and piezometers are surveyed monthly. Data from inclinometers and piezometers are reported to MDEQ and BLM yearly in GSM's Annual Reports. Four new inclinometer installations were completed in the fall of 1995. Down-hole extensometers will be installed in select inclinometer holes if the inclinometer becomes inoperable.

Protocols for actions to be taken if renewed ground movement is detected are outlined in GSM's December 23, 1994, letter to the MDEQ and BLM (Foster 1994). Pursuant to this letter, agency notification and review of block stability will occur if any of the following criteria are exceeded:

- An average groundwater increase in the Bozeman Unit within the Sunlight Block of greater than 1 foot during any 1-month period;
- A cumulative, average groundwater level increase of 10 feet in the Bozeman Unit within the Sunlight Block, with respect to November 1994 levels;
- If movement is indicated by inclinometers located within the Sunlight Block; or
- If consistent movement trends are discernible from geodetic monitoring data over a period of 2 months or more.

Should any of the outlined criteria be exceeded, GSM will notify the MDEQ and BLM by telephone, and follow-up with an explanation by letter.

Fire and Medical. The GSM Emergency Response Team is composed of 32 people, including 18 Emergency Medical Technicians (EMTs), some of whom have advanced training. The Emergency Response Team Call-Out Roster and RCRA Emergency Preparedness and Prevention Plan is posted in each applicable facility.

Emergency medical facilities are located at the mine site. If necessary, patients are transported to Butte, which has the nearest hospital with emergency facilities. GSM maintains fire prevention and control equipment at the mine site.

GSM is subject to the Federal Mine Safety and Health Act (MSHA) of 1977, which sets forth mandatory safety and health standards for surface metal and nonmetal mines, including open-pit mines. The purpose of these standards is the protection of life, promotion of health and safety, and prevention of accidents. Regulations promulgated under MSHA are codified under 30 CFR Subchapter N, Part 56.

GSM's Safety Manual (GSM 1993) provides safety rules for all portions of the mining operation, including practices in the mine area, ore processing facilities, maintenance and repair shops, warehouses, laboratory, and office. Each year, approximately 6,800 worker hours are dedicated to classroom safety training.

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Environmental Protection Measures

This section discusses environmental protection measures utilized during mine operations. Environmental protection measures utilized for reclaimed areas follow the reclamation plan as described in Section II.B.1.b, Existing Reclamation Plan.

Protection of Water Quality. The groundwater and surface water quality within the mine area is protected by use of water management practices that include active and passive groundwater controls, storm water controls, water quality monitoring and data reporting, water collection and treatment, and control of process solution.

Groundwater Controls. GSM manages groundwater on-site using drains and dewatering systems. The Arkose and Sunlight Springs are controlled with an approved drain system that keeps all water below the natural land surface beneath the West Waste Rock Dump complex. The water from the former springs is separated from acid generating waste rock by several feet of gravel, synthetic liner and soil material. The springs beneath the buttress dump are dewatered by upgradient wells in the Rattlesnake Block that route water to a land application disposal area northeast of Tailings Impoundment No. 2. A gravel drain system also underlies the buttress dump and, if the dewatering wells are not operating, the drain collects water that is then routed to Impoundment No. 2. Other water disposal options for buttress area groundwater are presently being examined by GSM.

Storm Water Controls. GSM maintains an approved storm water control system to prevent discharge of runoff from mine facilities into waters of the state of Montana. Storm water runon in the pit area is directed into the open pit via the haul road system. This water is then removed from pit dewatering sumps and directed into the GSM operational water treatment plant at the plant site. Storm water runon in the waste rock dump areas is intercepted by diversion ditches before it comes into contact with acid generating rock. This water is then directed into areas that promote infiltration and recharge to the underlying groundwater system. Precipitation that falls directly onto unreclaimed waste rock dumps typically puddles and evaporates and/or infiltrates into the dump surface where it is driven back to the atmosphere from heat produced in exothermic oxidation reactions (GSM 1995b, Appendix 5.5-1).

Any runoff that does occur directly from unreclaimed dumps and the tailings impoundment areas is contained by berms, and evaporates and/or infiltrates. Storm water and sediment control in soil stripping areas is managed by use of berms/infiltration swales, straw bail barriers and silt fencing. Storm water runoff and sediment from the access road system is controlled with sediment traps, straw bail barriers and silt fencing. The runoff from the soil stripping areas and access roads is allowed to exit into adjacent natural gulches, where it eventually infiltrates into the subsurface. Some runoff from the main access road is presently being diverted into natural drainage/infiltration basins west of Impoundment No. 1, until such time that GSM's west diversion system is completed. GSM has an approved storm water monitoring plan whereby storm water samples are collected, analyzed and the results reported to MDEQ.

Water Quality Monitoring and Data Reporting. GSM maintains an extensive array of groundwater monitoring wells and surface water monitoring sites (GSM 1996a [1996 Annual Report]). The monitoring sites are sampled and analyzed to ensure that water quality protection measures are functioning properly and provide an early-warning system to identify where additional controls may be needed. The monitoring frequency at each site varies from monthly to semi-annually, depending on location and proximity to mine facilities. Sites closest to the pit, waste rock dumps and the tailings impoundments are monitored more frequently. Monitoring results are reported to MDEQ and BLM annually.

Water Collection and Treatment. GSM collects acidic water that accumulates in the open pit using sumps. The water is pumped to the operational water treatment plant in the mill complex and then incorporated into the ore processing circuit. Acidic storm water runoff from the ore crushing stockpile is collected within a lined pond near the mill complex. The acidic Midas Spring discharge is collected by a drain system that reports to a holding tank. The holding tank pumps to the same lined pond that collects runoff from the ore pile. This water is then pumped to the operational water treatment plant and used in the ore processing circuit.

Control of Process Solution. Impoundment No. 1 is presently being dewatered by gravity drainage. During operations, the seepage from the impoundment is collected and pumped to Tailings Impoundment No. 2. Following mine closure, the remaining seepage will be pumped to a permanent water treatment plant before being discharged. At closure, the drainage from Tailings Impoundment No. 2 will be recycled back over the impoundment area and evaporated by spraying until the drainage approaches a near zero, steady-state flow. Any residual steady-state flow from Impoundment No. 2 will be directed to the permanent water treatment plant before being discharged. GSM also used secondary containment structures in the mill complex and along pipelines to prevent discharge to the environment if a spill or leak of process solution occurs. In addition, a cyanide neutralizing chemical (calcium hypochlorite) is kept on hand, and provisions are made to drain the process solution into Impoundment No. 2, if necessary.

Protection of Air Quality. Dust is suppressed at the mine site by regular water treatments or soil stabilizers. Drilling equipment at the mine site is equipped with water injection systems to moisten drill cuttings and minimize dust discharge.

Noxious Weed Control. Until bond release, all property within the permit boundary is inspected annually for noxious weeds. Noxious weeds within the permit boundary are chemically controlled as detailed in GSM's existing weed control plan, which is on file with the Jefferson County Weed Board. Noxious weed control results and a map are submitted to the agencies in each annual report.

Protection of Wildlife. Because of the high levels of CN in the tailings impoundments, GSM has had to develop a hazing program to deter waterfowl, and exclusion measures to deter other wildlife since the opening of Tailings Impoundment No. 1 in 1983. CN levels in Tailings Impoundment No. 1 have been kept below 50 ppm since 1994 by adding hydrogen peroxide. However, CN levels in Tailings Impoundment No. 2 remain high. In March 1996 CN levels in Impoundment No. 2 were 286 ppm; values of 25 to 50 ppm or less would have to be maintained to minimize wildlife mortalities from CN (USFWS 1991). GSM's program has grown over the years from a "daytime and shore patrol only" level to a full blown multifaceted program with 2 to 3 full time personnel 24 hours a day, 7 days a week. GSM reports wildlife mortality to the agencies in their annual reports.

Fencing and Passive Exclusion Measures. Tailings Impoundment No. 2 was designed to reduce the potential for exposure to wildlife. The surface area of water within the impoundment is kept as small as operationally possible by selective spigoting of slimes around the periphery, and by pumping reclaim water for use in the ore processing facility at a maximum possible rate. In addition, an 8-foot high page wire fence around both impoundments with 2-inch by 4-inch wire mesh prevents large mammals from entering the area. A 1-foot high berm constructed along the inside perimeter of the fence discourages small mammals from entering the tailings impoundment area by digging beneath the fence. An additional page wire fence 8 feet in height was erected around the pond located below the ore crushing area during the summer of 1995. The fence was built to prevent deer from accessing the lined pond area, where they might either become trapped or damage the liner.

Hazing and Monitoring Programs. Wildlife hazing, resuscitation, and mortality monitoring programs at the tailings impoundments have been implemented to minimize wildlife mortalities at the tailings impoundments. GSM has developed highly efficient techniques for hazing birds. These include:

- Intermittent firing of propane canons placed around the impoundments;
- Operation of a sound system which broadcasts rock music and more recently, recordings of predatory birds (hawks, falcons, eagles, etc.), and ultrasonic sound;
- 24-hour surveillance by mine personnel to haze away any observed incoming birds with shotguns and pistols that fire whistler and cracker shells;
- Pyrotechnic explosions, such as 4-inch waterproof fire crackers and whistlers;
- Operation of houseboats, hovercrafts, and small boats on the ponds to haze away incoming birds;
- Patrolling ponds at night using high-powered lights and strobes to intercept birds;
- Increasing hazing personnel during peak bird migration periods so that three persons patrol the impoundment area from 2 hours before daylight until 2 hours after dark;
- Training programs for accurate wildlife identification and safe handling; and
- In the cases where birds ignore hazing efforts, land in the tailings impoundments, and become sick, they are retrieved with a net and revived with amyl nitrate and oxygen (the same chemical used for human exposure to cyanide). Mortalities are reported annually to MDEQ and BLM.

Implementation of the cyanide destruction process will reduce cyanide levels in the tailings impoundments to levels considered safe for wildlife by approximately early to mid-1998. However, hazing and monitoring programs will continue at the same levels due to other, less acute hazards in the tailings impoundments, such as copper and other metals.

Protection of Historical and Archaeological Resources. If historical or archaeological sites are discovered during excavation, construction, or soil salvage, the work is halted immediately and the appropriate agencies are notified.

Protection of Public Health and Safety. Active portions of the mining area are fenced for public safety and wildlife protection. Abrupt pit perimeters will be bermed, signed, and fenced upon mine closure.

II.B.1.b Existing Reclamation Plan

The existing reclamation plan is described in detail within the Operating Permit (GSM 1995a, Section E, Reclamation Plan). For all areas except the open pit, objectives of the reclamation plan are to bring the final land use and vegetative cover to a level that is comparable to that of adjacent areas. Of the 2,336 acres of total disturbance, 1,892 acres would be revegetated, 236 acres would be undisturbed or have already been seeded and reclaimed, and 208 acres would not be revegetated (including steeply sloped and inaccessible areas in the pit and roads outside the disturbance boundary). The plan provides for topsoil and subsoil salvage, oxidized rock salvage, and reclamation of waste rock dumps, tailings impoundments, the plant site, utilities, roads, and other miscellaneous structures. Pit reclamation plans include berming and fencing abrupt pit walls, diverting surface water run-on, revegetating oxidized talus slopes and benches where feasible, and treating pit water to prevent objectional effluents from leaving the pit area.

GSM's original reclamation plan for Amendment 008 has been modified to address the ground movement that occurred in 1994 and the Constitutional issues regarding reclamation of the pit as required by the MMRA. Numerous reclamation studies were conducted in compliance with the stipulations of Amendment 008. The complete reference list of these studies, which have been supplied to the agencies, is provided in the Operating Permit (GSM 1995a, Cross References). The status and commitments related to the stipulations of Amendment 008 are discussed in the Summary in the beginning of this EIS, and in Section I.B.1, Stipulation Compliance, and Table I-1. Reclamation studies have concentrated on:

- Revegetation test plots on waste rock dumps evaluating success of reclamation on 3:1 versus 2:1 slopes;
- Tailings Impoundment No. 1 test reclamation plots evaluating the need for a clay cap;
- Oxidized waste rock cap characterization and selection criteria;
- Water movement within and acid-generation potential of waste rock dump material; and
- Erosion and vegetation cover comparisons with native reference areas.

Schedule

Concurrent Reclamation. Concurrent reclamation of mine facilities begins as soon as possible after they become permanently inactive. Over 118 acres of disturbance have been reclaimed to date, as detailed in the 1995 Annual Report (GSM 1996a). Reclamation, including waste rock dump slope reduction, oxidized waste rock capping, soil placement, and revegetation, was initiated in 1995 for portions of the East and South Waste Rock Dumps. The South Waste Rock Dump reclamation was delayed with the agencies' approval until the EIS is completed. The portion of the East Waste Rock Dump that was off-loaded to stop the ground movement was reclaimed in 1996.

Ultimate Reclamation. Table II-6 provides an estimated ultimate reclamation schedule for all project facilities.

Bonding Commitment

As of August 1997, GSM had posted a total bond of $38,043,902 to cover reclamation costs. The bond was updated in June 1997 with the required annual increment of $1,158,000. The bond also was updated in June 1996 with the required annual increment of $1,158,000, as well as an additional bond of $945,702 to increase the anticipated future water treatment needed based on pit inflow data. The original bonding commitment, as stipulated with Amendment 008 approval, required annual increments of $1,158,000 through 2002, and annual increments of $408,000 per year in 2003 and 2004. This was modified with *Interim Dump Plan* approval and preparation of the EIS. The total bond commitment will be reviewed by the agencies when a decision on the EIS has been made, regardless of which alternative is selected. Bonding requirements will be revised at that time according to which alternative is selected.

As stipulated in the MMRA, the total value of the bond is reviewed every 5 years and updated to compensate for inflation or other factors as needed. The 5-year review on GSM's bond, scheduled in 1995, was delayed until completion of this EIS.

Permanent Post-Mine Water Treatment Plant

GSM currently has a water treatment plant to treat pit water during operations. GSM's existing reclamation plan provides for the construction of a new permanent water treatment plant to treat the anticipated inflow into the pit, potential seepage from the waste rock dumps, and seepage from the tailings impoundments (GSM 1995a, Appendix 13). GSM has submitted a total of $5,304,702 to MDEQ as part of the surety bond for this facility to be constructed and operate as long as necessary to ensure that discharge from the mine site meets Montana water quality standards. The amount of the bond was calculated using worst-case hydrologic and

Table II-6

Reclamation Schedule for Project Facilities Under the No Action Alternative

Project Facility	Reclamation Activities	
	Start[1]	End
Exploration Disturbance Revegetation	On-going	
Waste Rock Dumps Recontouring (as completed)	1994	1998
Waste Rock Dump Capping, Topsoil Placement and Reseeding	1994	2000
Tailings Impoundment Stabilization (assumes 4 years to dry) Impoundment No. 1 Impoundment No. 2	 1993 1997	 1997 2001
Tailings Impoundment Capping, Topsoil Placement and Reseeding Impoundment No. 1 (assumes 8 to 10 years to consolidate) Impoundment No. 2 (assumes 4 years to consolidate)	 1994 1997	 2004 2001
Open Pit and Perimeter Reclamation	1997	1999
Removal of Structures, Solution Tanks and Equipment	1997	1999
Borrow Areas, Wing Dike, and Diversion Structure Reclamation	as constructed	1999
Haul and Secondary Road Revegetation	on-going	1999
Utility Corridor Reclamation	on-going	1999
Drill Hole Plugging	on-going	1999
Water Treatment Plant	Indefinite[2]	Indefinite[2]

[1] For concurrent reclamation to date, see annual report maps submitted to agencies.

[2] Reclamation of the water treatment plant would occur only if water treatment of pit water, tailings seepage, and waste rock seepage is no longer needed to meet Montana water quality standards. Reclamation of the water treatment plant would be completed within 2 years after treatment is no longer needed.

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economic assumptions. Given a conservatively-estimated rate of return, interest on the principal should be sufficient to pay for all maintenance, operations, and periodic replacement of the facility every 20 years. The agencies review the pit inflow data collected by GSM annually which is reported in GSM's annual reports. In June 1996, after agency review of the annual report for 1995, GSM submitted another bond increment of $945,702, to keep the water treatment bond adequate for treating 300 gpm of inflow. At the end of mine life, the surety bond portion for the permanent water treatment facility will be converted to a permanent trust fund and assigned to the state of Montana. The state of Montana will administer the fund until continued treatment is not necessary to meet Montana water quality standards.

Based on actual measured flows in 1995, potential pit dewatering outflow at the end of the *Interim Dump Plan* is estimated by GSM to be approximately 35 gpm (short-term). Tailings Impoundment No. 1 pumpback wells are expected to continue to collect and discharge approximately the current seepage rate of 266 gpm. Therefore, to accommodate pit inflows and pumpback well water from Tailings Impoundment No. 1, the permanent water treatment plant will need to treat an estimated 301 gpm of pit and tailings outflow (short-term) at the end of the *Interim Dump Plan* (Appendix A).

Over the long-term, pit inflows are estimated to increase to approximately 54 gpm. As Tailings Impoundment No. 1 dewaters, seepage from the impoundment will equilibrate at an estimated 200 gpm or less as the tailings become dry and the source of seepage that remains is primarily groundwater underflow. This water will continue to be routed to the permanent water treatment plant from the Tailings Impoundment No. 1 pumpback well system until water quality standards can be met. The dewatering of Tailings Impoundment No. 1 will require approximately 8 to 10 years.

Approximately 150 gpm of seepage from the reclaim ponds below the lined Tailings Impoundment No. 2 will have to be routed to the ore process plant during mine life. After mining stops, seepage from Impoundment No. 2 also will decrease over time as the tailings dewater and reclamation commences. After mining ceases, this water will be recycled and evaporated over the impoundment area. Seepage from Tailings Impoundment No. 2 will eventually equilibrate at approximately 10 gpm or less (Appendix A). This water will be treated in the permanent water treatment plant along with Tailings Impoundment No. 1 water.

Model estimates indicate that seepage from the West Waste Rock Dump will eventually need to be collected and treated to protect groundwater quality (Appendix J). An estimated 52 gpm of groundwater flow downgradient of the West Waste Rock Dump will require collection and treatment at the permanent water treatment plant.

To accommodate estimated long-term pit inflows (54 gpm), estimated long-term seepage/pumpback rates from Tailings Impoundment No. 1 (200 gpm), estimated long-term seepage/pumpback rates from Tailings Impoundment No. 2 (10 gpm), and estimated long-term groundwater capture/pumpback rates from the West Waste Rock Dump (52 gpm), the permanent water treatment plant will treat an estimated long-term inflow of 316 gpm (Appendix A).

If actual pit inflows or seepage from the waste rock dumps are higher than the estimates presented, the excess will be pumped to the pit for storage until the permanent water treatment plant can be modified to accommodate the additional flows. Based on a pit elevation of between 5,075 and 5,100 feet at the end of the *Interim Dump Plan* and a pond level storage change of approximately 30 feet, the pit could accommodate approximately 30 million gallons of short-term water storage capacity. If actual seepage rates from the tailings impoundments are higher than estimated, existing lined overflow basins south of Impoundment No. 2 would be used for short-term storage until the permanent water treatment plant can be modified to accommodate the additional flows. These basins can accommodate approximately 40 million gallons.

Disturbed areas related to the permanent water treatment facility are shown on Map I-2. The access road for the facility will extend along the corridor shown on Map I-2. Utility lines will follow the access road. GSM will monitor the quantity and quality of sludge produced at the permanent water treatment plant on a quarterly basis and provide this information to MDEQ and BLM on an annual basis. Based on initial results from samples collected at GSM's existing operational water treatment plant, the sludge produced from the permanent water treatment plant is not likely to be hazardous waste under the RCRA (GSM 1995b). Appendix C outlines the revised sludge disposal plan for the permanent water treatment plant.

It is estimated that sludge production at the permanent water treatment plant will be 17 cubic yards per day from plant start-up through year 10, and 21 cubic yards per day beyond year 10. The dewatered sludge will have a minimum solids content of 50 percent by weight. The sludge will be pumped to a sludge disposal landfill located on the surface of Tailings Impoundment No. 2. At the landfill, sludge will be disked, dried, and compacted, reducing the final volume. Landfill cells will be constructed with geomembrane liners. The tailings impoundment liner will provide a secondary leakage containment system. From plant start-up through year 10, two 184-foot square cells will be required. Beyond year 10, cells will be 200 square feet. Cells will be filled to a 20-foot depth. This corresponds to a storage capacity of 5 years worth of sludge production per cell. The final surface area of Tailings Impoundment No. 2 will be 185.5 acres, providing adequate storage area for over 1,000 years worth of sludge production. At cell closure, a geomembrane liner will be placed over the surface of the compacted sludge; stockpiled capping materials will then be placed over the geomembrane and revegetated (Appendix C).

Reclamation of the permanent water treatment plant and associated utility corridors and power lines will take place when treatment is no longer necessary. However, no site specific reclamation plan exists in GSM's current Operating Permit for the water treatment plant.

Soil Management

Topsoil and subsoil suitable for plant growth is removed and salvaged from slopes that allow safe operating practices. Soil salvage techniques, stockpile seed mixes, and suitability criteria are described in GSM's existing Operating Permit (Section E, Reclamation Plan, in GSM 1995a). In areas with limited soil availability, additional soil will be salvaged on steep slopes with modified equipment, or soils will be salvaged with a coarse fragment content that exceeds 50 percent by volume as previously approved by MDEQ and BLM. Salvage depths for topsoil and subsoil are staked according to soil surveys, and frequent quality checks are made during soil removal. Depth specifications for soil cover material, by mine facility area, are presented in Table II-7. Estimated soil requirements by mine facility area, for reclamation under the No Action Alternative are presented in Table II-8. The total estimated soil volume required for reclamation under the No Action Alternative is 4,154,700 cubic yards. The total estimated soil volume available is 3,831,800 cubic yards. Soil volumes and soil salvage plans are reported to MDEQ and BLM on an annual basis to ensure that soil volumes in stockpiles are sufficient to meet reclamation needs. Shortfalls in soil volume available will be compensated by soil from borrow areas in the tailings dam miscellaneous area, the buttress miscellaneous area, or the plantsite miscellaneous area.

Oxidized Rock Salvage

Oxidized waste rock has a reduced potential to generate ARD. Oxidized waste rock is salvaged from the pit to provide nearly neutral material for reclamation capping. Stockpiled oxidized waste rock includes some materials from oxidized mass-wasting deposits east of the pit. Depth specifications for neutral capping material, by mine facility area, are presented in Table II-7. Estimated oxidized rock requirements for reclamation under the No Action Alternative are presented in Table II-8. The total estimated volume of neutral capping material required for reclamation under the No Action Alternative is 3,851,300 cubic yards. The total estimated volume of neutral capping

Table II-7

Depth Specifications for Soil and Neutral Capping Requirements[1]

Mine Facility	Depth of Neutral Capping	Depth of Soil Cover	Total Depth of Capping Material
Sulfide Covered Areas:			
West Waste Rock Dump			
Dump Tops and Haulroads	24 inches	19 inches	43 inches
Dump Slopes and Haulroads	26.8 inches[2]	21.2 inches[2]	48 inches
East Waste Rock Dump			
Dump Tops and Haulroads	24 inches	24 inches	48 inches
Dump Slopes and Haulroads (2:1 Slopes)	26.8 inches[2]	26.8 inches[2]	53.6 inches
Dump Slopes and Haulroads (3:1 Slopes)	25.3 inches[2]	25.3 inches[2]	50.6 inches
Buttress			
Buttress Top and Haulroads	24 inches	24 inches	48 inches
Buttress Slope and Haulroads	25.3 inches[2]	25.3 inches[2]	50.6 inches
Tailings Area			
Tailings Sands Disturbance	24 inches	24 inches	48 inches
Pit			
Roads and Benches	24 inches	24 inches	48 inches
Plantsite Area			
Plantsite	24 inches	24 inches	48 inches
Non-Sulfide Covered Areas:			
Construction Buffers	0	6 inches	6 inches
Miscellaneous Areas	0	6 inches	6 inches

[1] These general depth specifications apply to all alternatives. The No Action Alternative also includes an additional 18-inch clay layer over the tailings impoundments.

[2] Soil and neutral capping depths on slopes have been adjusted to account for increased volume requirements. Actual depths are the same as on flat areas.

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Table II-6

Estimated Soil and Neutral Capping Requirements for Reclamation Under the No Action Alternative

Mine Facility	Disturbance Area (Acres)	Sulfide Covered (Acres)	Non-Sulfide Covered (Acres)	Neutral Capping Requirements (yd^3)	Soil Requirements (yd^3)
West Waste Rock Dump					
Dump and Haul Roads	415	415	0	1,425,700	1,128,100
Construction Buffer	98	0	98	0	79,000
Miscellaneous	38	0	38	0	30,300
Undisturbed or Seeded and Reclaimed	65	0	65	0	0
TOTAL	616	415	201	1,425,700	1,237,400
East Waste Rock Dump					
Dump and Haul Roads	312	312	0	1,058,300	1,058,300
Miscellaneous	27	0	27	0	22,000
TOTAL	339	312	27	1,058,300	1,081,400
Buttress					
Buttress and Haul Roads	75	75	0	248,800	248,800
Miscellaneous	94	0	94	0	75,900
TOTAL	169	75	94	248,800	324,700
Tailings Area					
Tailings	259	259	0	836,400	836,400
Miscellaneous	353	0	353	0	284,700
Undisturbed or Seeded and Reclaimed	159	0	159	0	0
TOTAL	771	259	512	836,400	1,121,100
Pit					
Roads and Benches	53	53	0	170,000	170,000
Highwall[1]	177	177	0	0	0
Miscellaneous	80	0	80	0	64,500
Undisturbed or Seeded and Reclaimed	2	0	2	0	0
TOTAL	312	230	82	170,000	234,500

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Table II-8 (Continued)

Mine Facility	Disturbance Area (Acres)	Sulfide Covered (Acres)	Non-Sulfide Covered (Acres)	Neutral Capping Requirements (yd^3)	Soil Requirements (yd^3)
Plantsite Area					
Plantsite	34	34	0	111,200	111,200
Miscellaneous	55	0	55	0	44,400
Undisturbed or Seeded and Reclaimed	9	0	9	0	0
TOTAL	**98**	**34**	**64**	**111,200**	**155,600**
Roads Outside Disturbance Boundary	**31**	**0**	**31**	**0**	**0**
TOTAL	**2,336**	**1,325**	**1,012**	**3,861,300**	**4,184,700**
TOTAL AVAILABLE[2]				**3,900,000**	**2,831,800**

[1] Pit "Highwall" includes all areas within the pit that would not be reseeded or revegetated due to steep slopes or inaccessibility.

[2] Any shortfalls of either topsoil or oxide rock for neutral capping will be provided from borrow areas in one of the following locations: (a) the tailings dam miscellaneous area; (b) the buttress miscellaneous area; or (c) the plantsite miscellaneous area.

Note: Totals may not add due to rounding.

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material available is 3,500,500 cubic yards. Suitable borrow materials also can be approved by the agencies as reclamation capping. Shortfalls in neutral capping material available will be compensated by material from borrow areas in the tailings dam miscellaneous area, the buttress miscellaneous area, or the plantsite miscellaneous area.

All oxidized rock planned for removal is sampled according to compositional variability and tested for its potential to generate ARD. Combined field observations and acidity testing determine whether or not the material is suitable for salvage and subsequent use as reclamation capping. As oxidized rock stockpiles are constructed, composites are collected and tested for their potential to generate ARD. The current soil and oxidized rock salvage and monitoring programs related to waste rock dumps also are described in the Operating Permit (GSM 1995a).

Field criteria used to segregate oxidized waste rock include:

- The rock must have an oxidized color on the surface, and when broken must retain the oxidized color; and
- With the aid of a hand lens, no pyrite should be observed on any broken surface.

If 90 percent of the rock observed within a unit meets these criteria, the material is saved for use as oxidized rock capping. If these criteria are not met, the material is either tested to determine the degree of ARD potential, or alternatively, discarded in a waste rock dump.

Based on kinetic testing and test plot data, all oxidized rock to be salvaged for reclamation capping material must have a net acid generating (NAG) final pH of 4.0 or greater (corresponding to a neutral rock unit) if it is to be used for reclamation without liming. Oxidized rock with a NAG pH between 3.2 and 4.0 will be limed to neutrality before it could be used for reclamation. Oxidized rock with a NAG pH of less than 3.2 will not be used as a reclamation capping material. Potential acidity results from oxidized and unoxidized rock samples are reported to the agencies in GSM's Annual Reports.

Waste Rock Dump Reclamation

Most waste rock dump slopes are reduced from angle of repose (1.4:1) to 2:1 for reclamation. The buttress and some waste rock dump slopes in the east dump complex are reduced to 3:1 slopes for stability reasons and visual aesthetics. All waste rock dump tops are sloped away from the dump face towards diversion channels. Waste rock dump slope faces are recontoured with not more than 200 feet of vertical distance between erosion control benches that contain diversion channels. All waste rock dump surfaces are capped with oxidized rock, lime (if needed based on acidity testing), and soil prior to seeding.

Oxidized Waste Rock Dump Cap. After reducing the slopes of the waste rock dumps and recontouring the surface, the new waste rock dump surface is tested for potential acid generation by analyzing composite samples taken from a survey controlled 100- X 100-foot grid established on the recontoured surface. The grid also is established to identify elevations that are used to verify thickness uniformity of reclamation cover layers. The number of samples tested for acidity is determined by the compositional variability observed in the dump material. Samples are submitted for either the modified Sobek method of acid-base accounting, or an on-site hydrogen peroxide based NAG pH test (for a description of the hydrogen peroxide NAG sampling protocol see GSM *1991 Annual Report Appendix E, Development of a Quick Test Method For Production of Acid Generating Capacity of Waste Rock*). If an on-site NAG pH testing method is used, a minimum of 1 sample in 50 is verified with the modified Sobek method (Montana State University [MSU] and Schafer and Associates 1987).

If samples have an acid-base accounting value using the modified Sobek method of greater than -20 (requiring amendment with 20 tons of lime or less per 1,000 tons of waste rock) and/or a NAG pH of greater than 3.2, then the dump surface will be treated as an oxidized cap

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and limed to neutrality before soil is placed and the cap is revegetated. If samples have an acid-base accounting value of less than -20 (requiring amendment with greater than 20 tons of lime per 1,000 tons of waste rock) and/or a NAG pH of less than 3.2, then the upper 6 inches of the dump will be limed to neutrality before a 24-inch-thick minimum cap of suitable or limed oxidized waste rock or borrow material is placed on the dump. GSM has the option of placing an additional 6 inches of oxidized waste rock or borrow material in the reclamation cap, in lieu of the liming requirement for the upper 6 inches of the acid waste rock dump surface.

Placement of oxidized capping material must meet uniformity criteria established by MDEQ and BLM (GSM 1995a, pp. 27 and 28). After the oxidized cap is in place, the survey grid with 100- X 100-foot spacing is reestablished on the dump, and samples will be collected again at each grid intersection. The samples will be visually examined, and representative samples analyzed for potential acidity. If potentially acidic areas are identified, more samples are tested. Those areas where more than one sample has a NAG pH of less than 4.0 are either top-dressed with enough lime to neutralize the cap, or recapped with suitable oxidized rock.

Waste Rock Dump Soil Placement. After the oxidized cap is in place and has been sampled for quality and verified for thickness, soil is spread. Placement of soil must meet uniformity criteria established by MDEQ and BLM (GSM 1995a, pp. 27 and 28). After soil placement, the surveyed 100- X 100-foot grid is reestablished to verify soil thickness. Soil depths are 19 inches on the west and south dump complexes and 24 inches on the east dump complexes. A composite soil sample from the in-place soil cap is collected every 5 to 10 acres and checked for texture, pH, Electric Conductivity (EC), potential acidity, soil nutrients, and sodium adsorption ratio (SAR).

The 2:1 to 3:1 slope surfaces with down-slope lengths greater than 30 feet have dozer gouges constructed in the final cover soil surface. Erosion/access benches are spaced across dump slopes at approximately 200-foot vertical intervals. The benches are designed to reduce waste rock dump slope lengths to minimize erosion on the slopes and intercept run-off. Drainage ditches on the benches slope back into the dump to collect runoff and route it to the dump diversion channels. Waste rock dump drainage ditches are constructed to handle the same design flow as the dump diversion channels. Benches also are used for construction access, seeding, and maintenance. As a result of the benches, the overall slopes are slightly less than 2:1 or 3:1.

Waste Rock Dump Revegetation. After soil placement, dump surfaces are fertilized and seeded with the seed mix shown in Table II-9. GSM has committed to keeping erosion below 2 tons per acre per year after successful vegetation establishment using a visual analysis and comparison with native reference areas. The use of mulch is just one of many erosion control practices GSM may choose to implement on any particular slope to reach that goal. Once the establishment of grasses and shrubs is successful, the reclamation plan provides for planting seedlings of Douglas fir, limber pine, and Rocky Mountain juniper in appropriate areas. The seedlings will be grown from seeds collected on or near the mine site. Rocky Mountain junipers will be planted at a density of 20 to 50 plants per acre. Tree planting will be arranged in wind breaks and thickets that vary from 10 to 50 trees per acre. North slopes will be planted with Douglas fir, south slopes with limber pine, and east and west slopes will be mixed.

Waste Rock Dump Monitoring. The following monitoring program is being conducted on waste rock dump reclamation plots. Waste rock dump toes are inspected annually for seeps during operations. Any seeps are collected and treated to prevent off-site impacts to water quality. Groundwater monitoring wells at the toe of the waste rock dumps are monitored for infiltration of contaminants each spring and fall, and reported to MDEQ and BLM on an annual basis (GSM 1995a, Appendix 12). Erosion on reclaimed slopes is monitored annually and after high precipitation events. Revegetation progress is monitored annually by measuring canopy coverage on revegetated slopes in

Table II-9

Waste Rock Dump Reclamation Seed Mix

Species	Common Name	Broadcast Application Rate (PLS lbs/acre)[1]
Grasses		
Agropyron smithii	Western wheatgrass	5.0
A. dasystachyum	Thickspike wheatgrass	5.0
A. spicatum	Bluebunch wheatgrass	5.0
A. riparium	Streambank wheatgrass	5.0
A. cristatum	Ephraim crested wheatgrass	4.0
A. trachycaulum	Pryor slender wheatgrass	3.0
Festuca ovina	Sheep fescue	1.0
Poa compressa	Canada bluegrass	0.5
Oryzopsis hymenoides	Indian ricegrass	0.5
Legumes		
Medicago sativa	Spredor II alfalfa	2.0
Melilotus officinalis	Yellow sweetclover	1.0
Onobrychis viciaefolia	Sainfoin	1.0
Shrubs and Forbs		
Artemisia tridentata	Big sagebrush	0.5
Chrysothamnus nauseosus	Rubber rabbitbrush	0.5
Atriplex canescens	Fourwing saltbush	1.0
Linum lewisii	Blue flax	1.0
	Total	36.0

[1] PLS = Pure Live Seed.

Note: The seed mixes can be modified at any time with agency approval.

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comparison with reference communities (GSM 1995a, pp. 24-28). Monitoring of soil chemistry, waste rock oxygen content, temperatures and moisture has been conducted annually on test plots established on the waste rock dumps to monitor reclamation success in limiting infiltration of moisture and the effectiveness of capping in slowing the oxidation reaction in the sulfide waste rock. The results of the research are presented in GSM's Permit Application, Volume 4, Appendix 5.5-1 (Schafer and Associates 1995a), Volume 5, Appendix 5.5-2 (Schafer and Associates 1995b), Volume 5, Appendix 5.5-2 (Richardson 1995) and the 1995 Annual Report (GSM 1996a).

Tailings Impoundment Reclamation

Tailings Impoundment Dewatering. Water from the impoundments is pumped and/or decanted to a sprinkler system along tailings beaches to aid evaporation. Chemical stabilization is used to prevent blowing dust and wind erosion during dewatering. Diversion channels above the impoundments prevent runon from upstream areas. During final stages of impoundment use, tailings deposition will be managed to create a gentle slope (approximately 0.75 percent) toward the diversion channels.

Based on the Tailings Consolidation Study conducted by GSM, the tailings impoundments must be reclaimed in stages (GSM 1996a [Appendix O, 1992 Annual Report]). Post-closure settling of the tailings impoundment surfaces is expected to be relatively minor along the outer perimeter (where the coarser tailings are deposited). Except for the seepage collection ponds, reclamation of the outer portion of the tailings areas can begin shortly after tailings impoundment decommissioning begins. Decommissioning of Tailings Impoundment No. 1 began in 1993. Incremental reclamation is expected to be conducted as consolidation is completed over an 8- to 10-year period (GSM 1996a [Appendix O, 1992 Annual Report]).

To prevent wind erosion on the dried portions of the tailings impoundments, a basal reclamation layer of borrow material is applied as soon as equipment can be operated on the dried impoundment surface. As soon as equipment can access the dried tailings surface, a surveyed 100- X 100-foot grid is established to produce reference elevations of tailings for verifying depths of reclamation covers placed on the impoundment surface. If necessary, to allow access over tailings slimes, a structural bridge of coarse material is used.

During decommissioning and reclamation of the tailings impoundments, seepage from the impoundments is collected and used in the process during mine life and treated after mine closure.

Tailings Impoundment Reclamation Cap. After the survey grid has been established, non-acid-producing local borrow material is applied until tailings consolidation has ceased and final grades have been achieved (the final impoundment grading plan is described in Appendix 9 of GSM's Operating Permit).

The MDEQ has approved the use of borrow material for capping the tailings surface, provided that:

- Borrow material used for capping has a loam soil texture or coarser, and an acid-base accounting (ABA) of 0 tons lime ($CaCO_3$)/1,000 tons of material or higher; and
- The survey grid is re-established after placement of the borrow material to verify 24 inches of borrow has been applied; and
- After placement on the tailings surface, the borrow material is sampled and re-tested for its acid-generating potential using the 100- X 100-foot survey grid points; results must be reported to MDEQ and BLM.

Placement of the borrow and soil material cap must meet uniformity criteria established by MDEQ and BLM. After testing verifies the suitability and thickness of local borrow, an 18-inch clay layer is placed on top of the 24 inches of local borrow to minimize seepage from the impoundments. The clay is compacted to a permeability of 10^{-6} centimeters per second (cm/sec) or less. The grid is established again to verify thickness and compaction specifications for clay placement. The final reclamation layers will be 2 lifts of soil totalling 24 inches. The subsoil will be applied first from 12 to 18 inches thick. Finally, a topsoil layer will be applied from 6 to 12 inches thick. Then the 100- X 100-foot survey grid will be re-established a final time to verify total soil replacement depths of 24 inches. Soil testing will be conducted and final revegetation will follow.

Tailings Impoundment Revegetation. After soil placement, the entire tailings impoundment area will be fertilized and drill seeded with the mix shown in Table II-10. This mix is designed to maximize soil water utilization, enhance evapotranspiration, and minimize infiltration.

Tailings Embankment Reclamation. The tailings embankment, constructed of the cycloned sand fraction of the tailings, has been deposited at a 3:1 slope or flatter. Any future sand embankments deposited at angles steeper than 3:1 will be reduced to 3:1 for reclamation. The embankment slopes will be capped with 24 inches of neutral rock or coarse borrow material, followed by 24 inches of soil. Testing to verify the quality and thickness of materials will be the same as proposed for the impoundment surface, except local borrow could have a coarse fragment content much higher than that on the impoundment surface. The embankment face will be seeded with the waste rock dump seed mix provided in Table II-9.

Tailings Impoundment Reclamation Monitoring. The majority of groundwater monitoring wells below the tailings impoundments are monitored for tailings seepage and trace metals four times per year. Five sites below Tailings Impoundment No. 2 are monitored monthly (GSM 1995a, Appendix 12). Monitoring of soil chemistry was conducted for 13 months on test plots established on the tailings impoundments to determine if acidification of capping materials will occur. The results of this research are presented by Dollhopf et al. in *The Effect of Earthen Covers on Tailings Impoundment Hydrology, Pore Water Chemistry, and Gas Content* (Dollhopf et al. 1995).

Pit Reclamation

The reclamation plan provides for pit reclamation that addresses safety concerns, oxidized waste rock capping and revegetation to prevent ARD (where feasible), wildlife habitat enhancement, and storm water and groundwater management.

Safety. Abrupt pit perimeters will be bermed and fenced. Warning signs will be placed around the pit perimeter.

Oxidized Waste Rock Capping and Revegetation. Trees will be planted around the pit perimeter and on talus slopes where safety, stability, and growth medium allow. Benches containing enough fine material to support plant life will be seeded and planted with trees where safety allows. Major benches that have sufficient width to allow machinery access, and which are not likely to become buried with rubble from pit walls over time, will be capped with 24 inches of oxidized waste rock followed by 24 inches of soil, and revegetated. Reclamation seed mixes are the same as that used on the tailings impoundments.

Wildlife Habitat Enhancement. The following additional pit reclamation procedures are designed to enhance wildlife habitat in the pit:

- Construction of five large raptor cavities (for golden eagles), at least 6 feet long, 4 feet deep, and 4 to 6 feet high. The cavities will be reinforced with concrete, if necessary.

- Construction of five small raptor cavities (for prairie and peregrine falcons), at least 24 inches long, 12 inches deep, and 12 inches high. These cavities also will be reinforced with concrete, if necessary.

- Ledges and small cavities constructed elsewhere in the pit highwall will provide suitable habitat for red-tailed hawks, great-horned owls, turkey vultures, and kestrels.

Table 5-10

Tailings Impoundment Reclamation Seed Mix

[illegible]	Common Name	[illegible]
Grasses		
Elymus junceus	Bozoiski Russian wildrye	6.0
Agropyron trichophorum	Pubescent wheatgrass	5.0
A. smithii	Western wheatgrass	4.0
A. cristatum	Ephraim crested wheatgrass	4.0
A. trachycaulum	Pryor slender wheatgrass	3.0
A. dasystachyum	Thickspike wheatgrass	2.0
Oryzopsis hymenoides	Indian ricegrass	0.5
Legumes		
Medicago sativa	Spreador II alfalfa	2.0
Melilotus officinalis	Yellow sweetclover	1.0
Shrubs		
Atriplex canescens	Four wing saltbush	1.0
	Total	28.5

[1] PLS = Pure Live Seed.

Note: The seed mixes can be modified at any time with agency approval.

- Construction of two horizontal excavations, at least 100 feet long, 10 inches high, and 18 inches wide, for Townsend's big-eared bats.

The exact location of the raptor cavities and bat excavations will be determined near the end of mine life when stable portions of the pit with suitable aspects can be most accurately identified.

Storm Water and Groundwater Management. Storm water run-on will be diverted around the pit to minimize water accumulation in the pit. Diversion channels will be designed to handle a 100-year, 1-hour precipitation event. Pit excavation under the *Interim Dump Plan* will cease at an elevation of approximately 5,075 feet, which is approximately 250 feet below the water table (5,325 feet). Water that accumulates in the pit bottom will be pumped to the permanent water treatment plant as necessary to maintain a pit pond elevation between 5,075 and 5,100. GSM estimates this will require approximately 48 to 54 gpm to be pumped from the pond (Hydrometrics Inc. 1995). This will maintain a pond surface area between 1.7 and 3.6 acres. Water will be removed by a submersible pump mounted from a floating barge within the pit pond. The discharge will be routed by flexible plastic pipe to the permanent water treatment plant before it is discharged by evaporation from a pond, land application, or discharge into a drainage under an approved Montana Pollution Discharge Elimination System (MPDES) discharge permit.

Plant Site and Building Reclamation

Reclamation of the plant site and other buildings will commence as soon as they are permanently inactive. Reclamation will include removal of all structures, unless a use can be found for the facility and that use is approved by MDEQ and BLM. Areas to be reclaimed will be tested for their acid generating potential prior to implementing reclamation procedures. If the site is acid producing, the waste rock dump reclamation cap will be used. If the sites are not acid producing, they will simply be resoiled and revegetated. Ripping may be used as a seed bed preparation technique on disturbed areas which have been subjected to excessive soil compaction. Disturbed areas for which this technique may be used include the plant site and associated operating facilities, as well as haul roads and access roads. Buildings will either be moved off-site, or dismantled with building materials placed in the on-site solid waste landfill. Foundations will be broken and buried prior to recontouring topography. Revegetation will be established with the same seed mix as is used on the tailings impoundments (Table II-10).

Decommissioning of Hazardous Material Containing Structures

During the partial and final mine closure periods, all contaminated equipment, structures, and soils will be properly disposed of or decontaminated in accordance with the applicable requirements in 40 CFR, parts 262 and 264. If GSM generates any hazardous waste by removing hazardous constituents during partial and final mine closure, all hazardous waste generated will be handled in accordance with all applicable requirements of 40 CFR part 262. GSM does not foresee generating any hazardous wastes after final mine closure. Decommissioning activities include:

- Disassembling of all structures that have been contacted by hazardous waste;
- Sampling of all materials that have been contacted by hazardous waste;
- Rinsing of all materials deemed a hazardous waste by the sampling program;
- Steam-cleaning of all materials deemed a hazardous waste by the sampling program;
- Re-sampling of all materials, residues, and waste waters after the cleaning program;
- Secondary cleaning of all materials after the re-sampling program; and
- Transportation (or arrangement of transportation) of all hazardous materials,

residues, and waste waters to a RCRA hazardous waste facility.

Road and Utility Corridor Reclamation

After removal of any structures, roads, utility corridors, and other ancillary disturbances will be contoured by pulling fill material up onto the cut or excavated areas of the roads or corridors. The goal of reclamation is to recontour disturbances to as close to original contours as possible. After contouring, the fill material will be visually inspected and sampled for potential acidity. If the sites are acid producing, they will be reclaimed with the waste rock dump cap. If the sites are not acid producing, they will simply be resoiled and seeded.

Successful reclamation test plot sites, as determined by the agencies, will remain in place unless they interfere with the operation and reclamation of the surrounding facility. Any disturbed test plot sites will be incorporated into the final reclamation plans. If any reclaimed site has to be redisturbed, soil will be resalvaged for subsequent reuse.

Revegetation mixes will vary for disturbed areas. The waste rock dump mix will be used on steep slopes, and the tailings impoundment mix will be used on gentle slopes and flat areas.

Solid Waste Landfill Reclamation

Operation of the solid waste landfill will continue until mine closure. Material placed in the landfill will be buried within the waste rock dump. Reclamation of the landfill will proceed in accordance with that outlined for the waste rock dumps.

Borrow Areas, Wing Dike, and Diversion Structure Reclamation

Soil will be salvaged from borrow area, wing dike, and diversion structures on all slopes less than 2:1. All of these facilities will be reclaimed incrementally as they are completed. All cut slopes will be constructed at a 2:1 slope or flatter. Soil will be placed where necessary for plant growth. Otherwise, soil will be stockpiled and later used for tailings impoundment reclamation. All slopes will be seeded with the waste rock dump reclamation seed mix. Flat areas will be seeded with the tailings impoundment seed mix. Excess diversion construction material will be stockpiled for reclamation capping materials.

Tailings Impoundment No. 1 wing dikes were reclaimed prior to approval of Amendment 008. Tailings Impoundment No. 2 wing dikes will be constructed to 2.5:1 slopes, covered with a minimum of 6 inches of soil, and seeded with the waste rock dump reclamation seed mix.

Standards for Successful Reclamation

The Operating Permit outlines goals for successful reclamation on test plots in terms of revegetation, soil erosion, soil chemistry, and treatment uniformity (GSM 1995a, pp. 24-28). Each of these criteria is described briefly below.

Revegetation. Revegetation success is to be evaluated by measuring canopy coverage on revegetated slopes and reference communities. In order to achieve reclamation "success", canopy coverage of revegetated slopes must be at least 90 percent of canopy coverage in reference communities.

Soil Erosion. Sedimentation on reclaimed slopes is compared to 110 percent of the sedimentation on reference areas. If the amount of sediment collected from reclaimed slopes and 110 percent of reference areas does not differ at the 90 percent probability level (using a paired t-test) during the final years of comparison, then erosion control will be considered successful.

Soil Chemistry. In order to be deemed successful, soil chemistry in all years must meet the following criteria:

- The pH within the cover soil and neutral waste rock layer must be within 2.0 units of initial pH, or not less than 5.5; and
- The soluble sulfate levels in cover soil and neutral waste rock cover must not increase

by more than 40 percent above initial measured levels in any cover layer; and

- If the sulfate increases by more than 40 percent, a stoichiometric calculation must be performed to identify the rate of acid migration in relation to the neutralization capacity of the cover system to estimate the length of time before pH decline occurs.

Treatment Uniformity. Treatments of cover or capping material will be deemed successful if the measured depth of cover material meets the following criteria:

- At least 90 percent of the design thickness must be measured at 50 percent or more of the sampling sites or transect locations; and
- At least 75 percent of the design thickness must be measured at 90 percent or more of the sampling sites or transect locations; and
- No sampling site may have less than 50 percent of the design waste rock or cover soil thickness.

infiltration. The preferred reclamation plan may be one that produces the least amount of waste rock dump acid seepage, while providing acceptable soil erosion rates and vegetation cover. If the reclamation plan can be proven to reduce seepage from the waste rock dumps while limiting soil erosion rates to 2 tons per acre per year, and providing for vegetation canopy cover of 50 percent or more, GSM may propose that MDEQ and BLM base reclamation success on these criteria.

Post-Mining Land Use

Post-mining land use will include potential future mining, wildlife habitat, hay production, and livestock grazing.

Post-Mining Topography

The pit area and final reclamation contours are shown in OP Map 6 in GSM's Operating Permit (GSM 1993a). Post-mining topography will include slopes and benches of comparable utility and stability to that of adjacent areas except in the pit area.

II.B.2 Continued Mining Beyond the Interim Dump Plan (Proposed Action)

Under the Proposed Action, MDEQ and BLM would approve a new Amendment to GSM's existing Operating Permit to allow mining to continue beyond the *Interim Dump Plan* until approximately 2006. The Proposed Action would expand the pit, expand waste rock disposal areas, and expand the buttress created to stabilize ground movements. Map II-1 shows the geographic relationship of the Proposed Action to existing permitted mining operations. Table II-11 presents acres of disturbance area, permit boundary area, and surface ownership under the Proposed Action.

New surface disturbance associated with the Proposed Action would occur on private lands (both fee simple and patented mining claims) controlled by GSM and on unpatented mining claims located on public lands administered by the BLM, Butte District Office. Smaller areas of disturbance would occur on state school trust lands administered by the Montana Department of Natural Resources and Conservation, Trust Land Management Division. (MDNRC review and approval of the Proposed Action is required for activity on state school trust surface and/or mineral estate prior to any disturbance on these lands.) The permit boundary would expand to include an additional 631 acres of GSM-owned land, 323 acres of BLM-administered land, and 100 acres of state school trust land. The disturbance area would expand to include an additional 517 acres of GSM-owned land, 75 acres of BLM-administered land, and 35 acres of state school trust land. Total disturbance under the Proposed Action occurring above state school trust subsurface lands (see Table II-12) would include 417 acres of sulfide-covered disturbance and 301 acres of non-sulfide covered disturbance, for a total of 718 acres of disturbance.

The reclamation plan under the Proposed Action differs from the current reclamation plan with respect to the size of the surface disturbance requiring reclamation, the capping material required for reclaiming the tailings impoundments and the reclamation schedule.

II.B.2.a Proposed Mining Operations

Continued mining under the Proposed Action would be accomplished using the same general open-pit mining methods and equipment described for the No Action Alternative. The Proposed Action would not change the ore and waste rock excavation rate. The mining schedule would be extended, however, from the year 1997 to approximately 2006. Ore tonnage processed under the Proposed Action would be 55 million tons, compared to approximately 34.1 million tons processed under the No Action Alternative. The pit configuration would be altered and its volume expanded to include the new ore and waste rock tonnage. Map II-1 shows a comparison of the pit disturbance area under the No Action Alternative and after the Proposed Action is complete in approximately 2006. The redesign of the pit would require modification of the pit's water diversion structures.

The mine would continue to operate 24 hours per day, 7 days per week, with a work force of approximately 200. Work force reductions would occur and work hours for mine employees would be shortened after major waste rock stripping efforts are completed.

Waste Rock Dumps and Buttress

Waste rock production rates under the Proposed Action would remain the same as those described for the No Action Alternative. However, under the Proposed Action, the total excavated waste rock tonnage would increase approximately 113 million tons because of the longer mine life. The total waste rock tonnage that would be excavated through 2006 is estimated to be approximately 432 million tons.

The waste rock dump designs at the mine site were revised for the Proposed Action to avoid potentially unstable geologic conditions. The redesign of the waste rock dump facilities would result in changes to both waste rock dump locations and heights. Map II-1 shows the

Table S-11

Surface Ownership of Disturbance and Permit Boundary Area Under the Proposed Action (Acres)

Facility/Area	Private	BLM	State of Montana	TOTAL
PERMIT BOUNDARY AREA:				
Existing[1]	*3,792*	*1,219*	*60*	*5,071*
Proposed	*631*	*323*	*100*	*1,054*
Total	*4,423*	*1,542*	*160*	*6,125*
DISTURBANCE AREA:				
West Waste Rock Dump				
Existing[1]	138	478	0	616
New	0	0	0	0
Total	138	478	0	616
East Waste Rock Dump				
Existing	253	76	0	329
New	240	75	35	350
Total	493*	151	35	679*
Buttress				
Existing	166	3	0	169
New	141	0	0	141
Total	283*	3	0	286*
Tailings Area				
Existing	769	2	0	771
New	94	0	0	94
Total	863	2	0	865
Pit				
Existing	275	37	0	312
New	0	0	0	0
Total	299*	37	0	336*
Plantsite Area				
Existing	81	17	0	98
New	33	0	0	33
Total	170*	17	0	187*
Roads				
Existing	31	0	0	31
New	0	0	0	0
Total	24*	0	0	24*
TOTAL DISTURBANCE AREA				
Existing[1]	1,723	613	0	2,336
New	517	75	35	627
Total	2,240	688	35	2,963

[1]Existing is defined as occurring through the *Interim Dump Plan.*

Note: Totals may not add due to rounding.

* Totals do not add due to overlap of facilities in the following areas:
  - The East Waste Rock Dump would expand into 5 acres of previously disturbed land in the roads area.
  - The plantsite area would expand into 10 acres of previously disturbed land in the East Waste Rock Dump, and 48 acres of previously disturbed land in the buttress area.
  - The pit would expand into 24 acres of previously disturbed land in the East Waste Rock Dump.
  - The buttress would expand into 2 acres of previously disturbed land in the roads area.

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Table II-12

Disturbance Occurring Above State School Trust Subsurface Lands
Proposed Action

Mine Facility	State School Trust Subsurface Sections Affected	Surface Disturbance (Acres)	Sulfide Covered (Acres)	Non-Sulfide Covered (Acres)
East Waste Rock Dump				
Dump and Haul Roads	S17, S20, S21	303	303	0
Construction Buffer	S16, S17, S20, S21	87	0	87
Sheep Creek Diversion	S16, S20, S21	22	0	22
Miscellaneous Disturbance	S16, S17, S20, S21	30	0	30
Buttress				
Buttress and Haul Roads	S28	2	2	0
Construction Buffer	S28	8	0	8
Tailings Area				
Tailings	S28, S33	112	112	0
Seeded Area	S28, S33	6	0	6
Miscellaneous Disturbance	S28, S33	126	0	126
Plantsite Area				
Miscellaneous Disturbance	S20	23	0	23
TOTAL		718	417	301

Note: Totals may not add due to rounding.

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existing and proposed waste rock dump and buttress layout.

Waste rock dump construction methods under the Proposed Action would remain unchanged from those described for the No Action Alternative. Expansion of the waste rock dump facilities would require construction of new storm water diversion channels to prevent surface water from contacting acid producing waste rock materials. These include a new diversion channel for Sheep Rock Creek. Retention berms would continue to be constructed after soil stripping. The locations of existing diversion channels and proposed new diversion channels and retention berms are discussed in detail in Chapter IV.

Ore Processing

The methods, equipment, and ore processing rate for mining described in the No Action Alternative would remain unchanged under the Proposed Action. Annual ore production rates would remain approximately 2.5 million tons per year. As discussed in Section II.B.1.a, Current Mining Operations, ore is crushed at the plant site and gold is extracted using a vat cyanide process with sand tailings retreatment.

INCO SO_2/Air Cyanide Destruction Process

The INCO SO_2/Air cyanide destruction process described for the No Action Alternative would continue under the Proposed Action. The circuit is designed to destroy cyanide in the tailings materials prior to sending them to the tailings disposal facility. Construction of the system was scheduled to be completed in late 1997; cyanide concentrations of at least 30 ppm or below will be achieved by early to mid-1998. The process will alleviate the hazards to wildlife and reduce the risks of groundwater contamination associated with cyanide in the tailings impoundments.

Tailings Impoundments

The tailings impoundments would not require modifications under the Proposed Action. As of December 31, 1995, approximately 29.0 million tons of tailings had been deposited in two impoundments. At that time, Tailings Impoundment No. 1 was at capacity and Tailings Impoundment No. 2 had a remaining capacity of approximately 27.3 million tons. Thus, the combined capacity of both impoundments is approximately 56.3 million tons of tailings. In total, approximately 55 million tons of tailings would be produced through completion of the Proposed Action. The existing capacity is sufficient to accommodate the tailings generated from the Proposed Action, and the 6-hour Probable Maximum Precipitation Event (PMP) with 5 feet of freeboard on the embankment.

Ancillary Mining Facilities

Continued mining under the Proposed Action would use the existing administration buildings, mining and equipment maintenance shops, assay and metallurgical laboratory, fueling facilities, and other support facilities described in the No Action Alternative. No new ancillary mining facilities would be needed to support continued mining.

Hazardous Materials Management

The production rate of hazardous materials under the Proposed Action would remain approximately the same as the existing production rate. No new types of hazardous waste are expected to be generated under the Proposed Action.

The number of shipments of hazardous materials and hazardous waste transported to and from the mine site per week under existing operations would not change under the Proposed Action. Hazardous materials would continue to be transported to the mine site by DOT-regulated transporters and stored on-site in DOT-approved containers. Secondary spill containment structures would continue to be provided for storage containers. All hazardous materials would continue to be stored on private land.

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Spill Prevention, Containment, and Release Reporting

GSM's existing Spill Contingency Plan would remain the same for the Proposed Action. (See Section II.B.1.a, Current Mining Operations, for a description.)

Energy Demand and Supply

No additional electrical or gas distribution lines would be required for the Proposed Action, and the rate of energy consumption would remain unchanged. Small portable generators would continue to be used for emergency lighting. Machinery would continue to be powered by gasoline and diesel fuel.

Water Demand and Supply

No new water sources would be required under the Proposed Action, and the rate of water consumption would remain unchanged. Water for ore processing and dust suppression would continue to be supplied by the Jefferson Slough, a groundwater well, and recycled water from the tailings impoundments and the pit. Potable water would continue to be provided by treating water pumped from the Jefferson Slough and in portable containers supplied by a local vendor.

Water Drainage and Surface Water Management

The locations of surface water diversion channels would be modified to conform to the proposed pit and dump plan under the Proposed Action (GSM 1995b, Exhibit 4-1). Although the locations of diversion channels would be modified for the Proposed Action, the size of the channels would be unchanged from current operations. Designs for rip-rap diffusion structures and sediment control berms also would remain the same as those approved under current operations.

Pit Water. During mine operations, water entering the pit area sumps would continue to be pumped to the operational water treatment facility at the plant site prior to use in ore processing. At mine closure, pit water would be stored in the pit and eventually routed to the permanent water treatment facility.

Tailings Impoundments. Two diversion channels, referred to as the east and west diversion channels, would continue to route surface flow around both impoundments under the Proposed Action.

Waste Rock Dumps. Under the Proposed Action, the dump-related diversion channels would be sized for the 100-year, 1-hour precipitation event which is expected to yield the highest peak flows for a 100-year recurrence interval event. This is the same design that was presented to MDEQ for the *Interim Dump Plan* and approved in 1995.

Sheep Rock Creek. Under the Proposed Action, a diversion structure would be created to divert the upper reaches of Sheep Rock Creek into an unnamed tributary of Conrow Creek (see Map II-1). Sheep Rock Creek is an ephemeral stream that flows in response to precipitation events. Conrow Creek is a tributary of the Boulder River that runs southeast, away from the East Waste Rock Dump. The diversion channel would be approximately 3,720 feet long and 6 feet deep, with a bottom width of approximately 16 feet, and outside slopes of approximately 2:1. It would be constructed of earthen, natural materials, and would include one small outfall structure. Construction would involve approximately 12 acres of miscellaneous disturbance. Material selection, placement, and final grade would ensure that Sheep Rock Creek would not come into contact with acid producing waste rock. Sediment control berms would be constructed along the channel to help control erosion. A cross-section of this structure is shown in Figure II-2. The diversion channel would be sized to accommodate flows equaling the one-half PMF (approximately 976 cubic feet per second [cfs], based on a runoff curve number of 50). The diversion structure would be a permanent facility, maintained by Golden Sunlight. Upon selection of the Proposed Action, an appropriate bond would be determined for the facility. The disturbance associated with the facility would be

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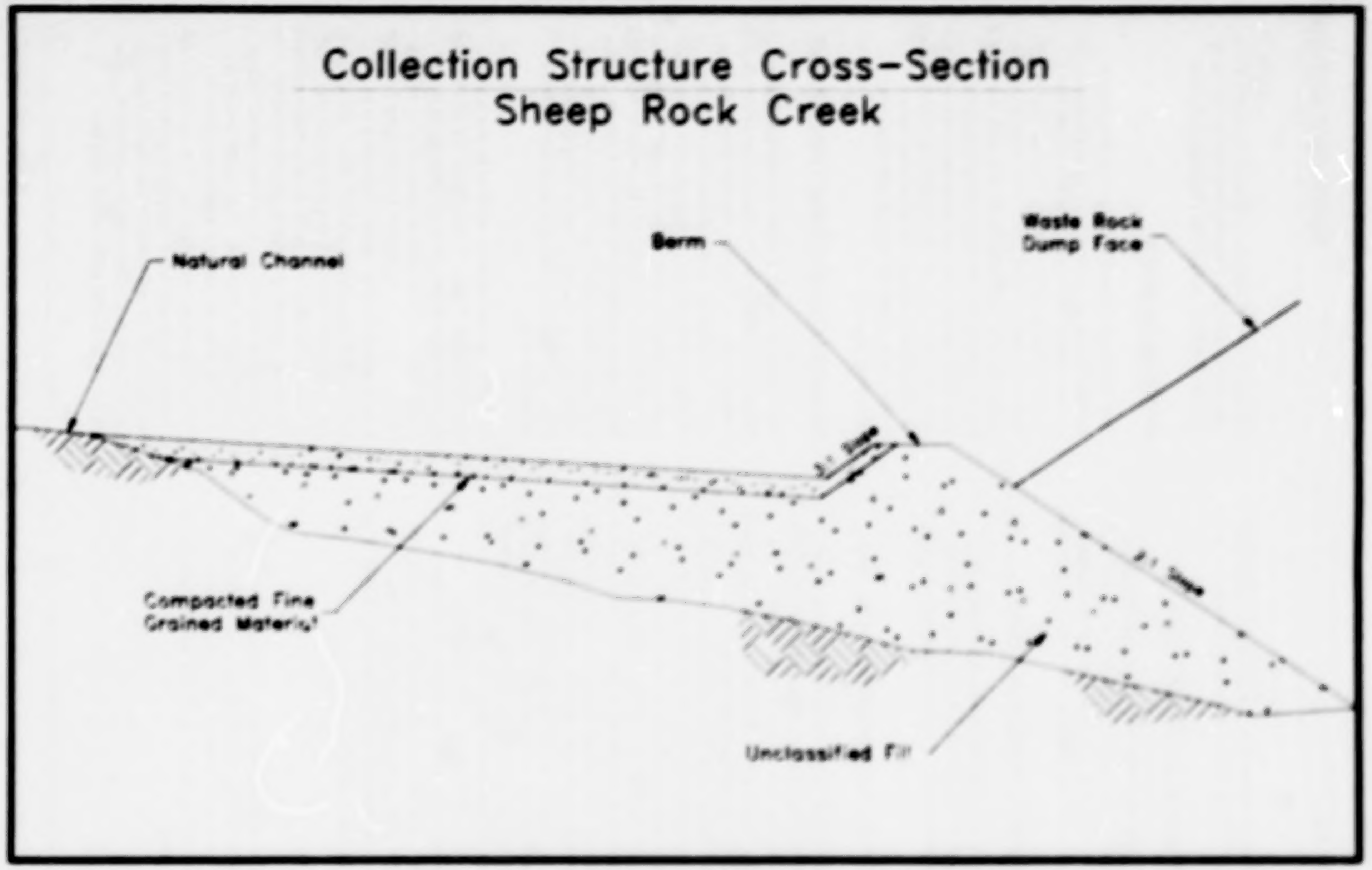

FIGURE II-2 COLLECTION STRUCTURE CROSS-SECTION - SHEEP ROCK CREEK - GOLDEN SUNLIGHT MINE

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reclaimed as described for other miscellaneous areas within the mine disturbance area.

Emergency and Contingency Plans

Emergency planning and response measures implemented for existing operations, described in Section II.B.1.a, Current Mining Operations, would remain the same for the Proposed Action.

Environmental Protection Measures

Existing environmental protection measures, described in Section II.B.1.a, Current Mining Operations, would continue under the Proposed Action.

II.B.2.b Proposed Reclamation Plan

The reclamation plan for the Proposed Action differs from the current reclamation plan with respect to the size of the surface disturbance requiring reclamation, the type of capping layers required for reclaiming the tailings impoundments, and the reclamation schedule. All surface disturbances within the permit boundary would undergo some form of reclamation activities. Of the 2,884 acres of total surface disturbance, 2,386 acres would be revegetated, 198 acres would be undisturbed or have already been seeded and reclaimed, and 300 acres would not be revegetated. The areas that would not be revegetated include "highwall" areas of the pit (steeply sloped and inaccessible areas) and other areas with potential future use such as the permanent water treatment plant, monitoring wells, parking areas, and access roads to these facilities. These areas would be reclaimed and revegetated as part of the reclamation plan when it is determined that they are no longer needed.

Schedule

Concurrent Reclamation. Concurrent reclamation would continue as implemented under the existing reclamation plan. (See Section II.B.1.b, Existing Reclamation Plan, for a description.)

Ultimate Reclamation. Table II-13 provides an estimated ultimate reclamation schedule for all project facilities under the Proposed Action.

Bonding Commitment

The bonding commitment for the Proposed Action would be determined as described under the No Action Alternative (see Section II.B.1.b, Existing Reclamation Plan). The current bond amount totals $35,043,802. Bonding would be reviewed and updated by MDEQ and the BLM if the Proposed Action Alternative is selected. The bond would also be reviewed and updated every 5 years, as per the MMRA, to compensate for inflationary effects, and for any minor revisions or amendments to the approved operating permit.

Permanent Post-Mine Water Treatment Plant

The same permanent water treatment plant design described for the No Action Alternative in Section II.B.1.b, Existing Reclamation Plan, would be used to treat inflows into the pit, tailings impoundment seepage, and waste rock dump seepage under the Proposed Action (Appendix A). If the life of the mine is extended, GSM would continue to monitor inflows, seeps, and pumpback rates, and adjust bonding as required to permanently treat seepage from these facilities (see the Bonding Commitment section above).

Potential pit dewatering outflow at the end of the Proposed Action is estimated by GSM to be up to 94 gpm if the pit is allowed to fill to the 5,080 feet elevation and evaporate at a rate of 82 gpm, or up to as much as 102 gpm if the pit is kept pumped dry. GSM estimates that the current Tailings Impoundment No. 1 pumpback well discharge rate of 288 gpm would decrease over the next 6 to 10 years as the impoundment dewaters. Seepage from Impoundment No. 1 is expected to equilibrate at an estimated 200 gpm or less at mine closure. This water would be routed to the permanent treatment plant from the Tailings Impoundment No. 1 pumpback well system. Seepage from Tailings Impoundment No. 2 would be collected in the reclaim ponds below the impoundment and recycled into the impoundment and evaporated until the

Table II-13

Reclamation Schedule for Project Facilities Under the Proposed Action

[redacted]	[redacted]	[redacted]
Exploration Disturbance Revegetation	On-going	
Waste Rock Dumps Recontouring (as completed)	1994	2008
Waste Rock Dump Capping, Topsoil Placement and Reseeding	1998	2007
Tailings Impoundment Stabilization		
Impoundment No. 1	1993	1997
Impoundment No. 2 (assumes 4 years to run low grade and evaporate process water)	2008	2010
Tailings Impoundment Capping, Topsoil Placement and Reseeding		
Impoundment No. 1 (assumes 8 to 10 years to consolidate)	1994	2004
Impoundment No. 2 (assumes 8 to 10 years to consolidate)	2008	2018
Open Pit and Perimeter Reclamation	1998	2009
Removal of Structures, Solution Tanks and Equipment	2008	2009
Borrow Areas, Wing Dike, and Diversion Structure Reclamation	as constructed	2009
Haul and Secondary Road Revegetation	Ongoing	2009
Utility Corridor Reclamation	Ongoing	2009
Drill Hole Plugging	Ongoing	2009
Water Treatment Plant	Indefinite[2]	Indefinite[2]

[1] For concurrent reclamation to date, see annual report maps submitted to agencies.

[2] Reclamation of the water treatment plant would occur only if water treatment of pit water, tailings seepage, and waste rock seepage is no longer needed to meet Montana water quality standards. Reclamation of the water treatment plant would be completed within 2 years after treatment is no longer needed.

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dewatered seepage rate from Impoundment No. 2 equilibrates at an estimated 10 gpm or less. This water would then be treated in the permanent water treatment plant along with the long-term seepage from Tailings Impoundment No. 1. Dewatering of Tailings Impoundment No. 2 would require 8 to 10 years after mine closure. Model estimates indicate that seepage from the West Waste Rock Dump will eventually need to be treated to protect groundwater quality (Appendix J). An estimated 52 gpm of groundwater flow downgradient of the West Waste Rock Dump would require long-term treatment at the permanent water treatment plant under the proposed.

To accommodate pit outflow and pumpback well water from Tailings Impoundments No. 1, the treatment facility would have to treat an estimated 254 gpm (short-term) at the end of the Proposed Action (302 gpm with no pit pond). This treatment rate would increase an estimated 10 gpm after the seepage from Tailings Impoundment No. 2 is routed to the treatment plant, and an additional estimated 52 gpm after groundwater flow downgradient of the West Waste Rock Dump begins to be treated. Thus, the required long-term treatment capacity of the permanent water treatment plant under the Proposed Action is estimated to be 316 gpm (364 gpm with no pit pond). The current water treatment plant design includes contingencies to handle up to 382 gpm (Appendix A).

If actual pit inflows or seepage from the waste rock dumps are higher than the estimates presented, the excess would be pumped to the pit for storage until the permanent water treatment plant could be modified to accommodate the additional flows. Based on a pit lake elevation of 5,080 feet, and a pond level storage change of approximately 30 feet, the pit can accommodate approximately 40 million gallons of short-term water storage capacity at this level. If actual seepage rates from the tailings impoundments are higher than estimated, existing lined overflow basins south of Impoundment No. 2 would be used for short-term storage until the permanent water treatment plant could be modified to accommodate the additional flows. These basins can accommodate approximately 40 million gallons.

The sludge disposal plan for sludge produced at the permanent water treatment plant would be the same as described for the No Action Alternative in Section II.B.1.b, Existing Reclamation Plan. The revised sludge disposal plan is provided in Appendix C. GSM would monitor the quantity and quality of sludge produced on a quarterly basis and provide this information to MDEQ and BLM on an annual basis. Other treatment options would be examined during the mine life. If more viable alternative treatments or technological advances become known, closure plans would be modified and re-submitted to the agencies for approval.

Prior to construction of the treatment plant, soil would be salvaged from the plant area and stored within the disturbance boundary shown on Map I-2. Reclamation of the treatment plant and associated utility corridors and power lines would take place when treatment is no longer necessary. Upon reclamation, the treatment plant would be removed and foundations buried. The facility site would be sloped to approximate natural contours, and covered with salvaged soil. Soil in sludge-drying areas would be tested prior to seeding and amendments would be added, as necessary, to meet Montana state standards for waste rock reclamation cover-soil. Seeding would take place using the tailings impoundment seed mix (see below).

Soil Management

Soil management practices would remain the same as those described for the No Action Alternative. Topsoil and subsoil suitable for plant growth would continue to be removed and salvaged from slopes that allow safe operating practices. Depth specifications for soil cover material would be the same as those described for the No Action Alternative (see Table II-7). Estimated soil requirements, by mine facility area, for reclamation under the Proposed Action are presented in Table II-14. The total estimated soil volume required for reclamation under the Proposed Action is 5,622,300 cubic yards. The

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Table 3-14

Estimated Soil and Neutral Capping Requirements for Reclamation Under the Proposed Action

Mine Facility	Disturbance Area (Acres)	Sulfide Covered (Acres)	Non-Sulfide Covered (Acres)	Neutral Capping Requirements (yd³)	Soil Requirements (yd³)
West Waste Rock Dump					
Dump and Haul Roads	415	415	0	1,425,700	1,128,100
Construction Buffer	98	0	98	0	79,000
Miscellaneous	38	0	38	0	30,200
Undisturbed or Seeded and Reclaimed	65	0	65	0	0
TOTAL	616	415	201	1,425,700	1,237,300
East Waste Rock Dump					
Dump and Haul Roads	505	505	0	1,696,000	1,696,000
Construction Buffer	113	0	113	0	91,200
Miscellaneous	52	0	52	0	42,100
TOTAL	670	505	165	1,696,000	1,829,300
Buttress					
Buttress and Haul Roads	217	217	0	720,000	720,000
Construction Buffer	47	0	47	0	37,600
Miscellaneous	2	0	2	0	1,400
TOTAL	266	217	49	720,000	759,000
Tailings Area					
Tailings	340	340	0	1,125,600	1,125,600
Miscellaneous	394	0	394	0	317,700
Undisturbed or Seeded and Reclaimed	122	0	122	0	0
TOTAL	856	340	516	1,125,600	1,443,300
Pit					
Roads and Benches	19	19	0	60,300	60,300
Highwall[a]	235	235	0	0	0
Miscellaneous	80	0	80	0	64,500
Undisturbed or Seeded and Reclaimed	2	0	2	0	0
TOTAL	336	254	82	60,300	124,800

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Table II-14 (Continued)

Mine Facility	Disturbance Area (Acres)	Sulfide Covered (Acres)	Non-Sulfide Covered (Acres)	Neutral Capping Requirements (yd³)	Soil Requirements (yd³)
Plantsite Area					
Plantsite	35	35	0	112,300	112,300
Miscellaneous	143	0	143	0	115,600
Undisturbed or Seeded and Reclaimed	9	0	9	0	0
TOTAL	187	35	152	112,300	227,900
Roads Outside Disturbance Boundary	24	0	24	0	0
TOTAL	2,984	1,774	1,190	6,140,100	5,622,300
TOTAL AVAILABLE				6,185,700	6,575,300

[1] Pit "Highwall" includes all areas within the pit that would not be reseeded or revegetated due to steep slopes or inaccessibility.

Note: Totals may not add due to rounding.

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total estimated soil volume available is 6,375,300 cubic yards. Soil volumes and soil salvage plans would continue to be reported to MDEQ and BLM on an annual basis to ensure that soil volumes in stockpiles are sufficient to meet reclamation needs.

Oxidized Rock Salvage

To provide neutral material for reclamation capping oxidized waste rock would continue to be salvaged from the pit using the methods and procedures described for reclamation under the No Action Alternative. Depth specifications for neutral capping material would be the same as those described for the No Action Alternative (see Table II-7). Estimated oxidized rock requirements for reclamation under the Proposed Action are presented in Table II-14. The total estimated volume of neutral capping material required for reclamation under the Proposed Action is 5,140,100 cubic yards. The total estimated volume of neutral capping material available is 6,195,700 cubic yards. Potential acidity results from oxidized and unoxidized rock samples would continue to be reported to MDEQ and BLM in GSM's Annual Reports. Suitable borrow materials could be used in lieu of oxidized waste rock if approved by the agencies (also see No Action Alternative).

Waste Rock Dump Reclamation

GSM would reclaim the waste rock dumps using the same general methods and procedures described for reclamation under the No Action Alternative. Most waste rock dump slopes would be reduced to 2:1 for reclamation, but the buttress and some waste rock dump slopes in the east dump complex would be reduced to 3:1. The upper 6 inches of the oxidized cap layer would still be limed to neutrality before placement of soil, if required by testing results. Soil placement depths would continue to be 19 inches on the West and South Waste Rock Dumps, and 24 inches on the east dumps. Dozer gouges and erosion control benches would continue to be used as described for reclamation under the No Action Alternative. Placement of oxidized capping material and soil would be required to meet uniformity criteria established by MDEQ and BLM.

Waste rock dump revegetation would occur as described for the No Action Alternative. After soil placement, dump surfaces would be fertilized and seeded with the seed mix shown in Table II-9. Waste rock dump monitoring would continue as described for the No Action Alternative.

Tailings Impoundment Reclamation

All aspects of tailings impoundment reclamation, including dewatering, revegetation, tailings embankment reclamation, and monitoring would be the same as described under the No Action Alternative, with the exception of the reclamation cap. Amendment 008 approval stipulated that an 18-inch clay layer was to be placed on top of the 24 inches of local borrow to minimize seepage from the impoundments. The additional 24 inches of soil would then be placed on top of the clay layer before seeding. Based on tailings test plots conducted on the impoundment surface at the mine site, the Proposed Action would only require the 24 inches of local borrow and 24 inches of soil. No clay layer would be used to minimize seepage from the impoundments.

Pit Reclamation

The Proposed Action allows the pit to partially fill with water following the end of mining. It is estimated that groundwater outflow would occur when the pit pond reaches an elevation of approximately 5,050 feet (contact of bedrock and colluvium). To eliminate groundwater outflow, GSM would remove approximately 54 gpm from the pit pond to maintain the area as a sink with a pond elevation below 5,050 feet (Hydrometrics Inc. 1995). This would maintain a pit pond surface area of approximately 37.6 acres. Water would continue to be removed using the same methods and procedures described for the No Action Alternative (see Section II.B.1.b, Existing Reclamation Plan).

Plantsite and Building Reclamation

Same as for the No Action Alternative.

Decommissioning of Hazardous Material Containing Structures

Same as for the No Action Alternative.

Road and Utility Corridor Reclamation

Same as for the No Action Alternative.

Solid Waste Landfill Reclamation

Same as for the No Action Alternative.

Borrow Areas, Wing Dike, and Diversion Structure Reclamation

Same as for the No Action Alternative.

Standards for Successful Revegetation

Same as for the No Action Alternative.

Post-Mining Land Use

Same as for the No Action Alternative.

Post-Mining Topography

The pit area and final reclamation contours are shown in Exhibit 1-2 of GSM's Permit Application (GSM 1995b). Post-mining topography would include slopes and benches of comparable utility and stability to that of adjacent areas except in the pit area.

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II.B.3 Return Diversion Alternative

This alternative was formulated to address:

- Potential impacts to water quality in Conrow Creek and the Boulder River watershed from increased discharge volumes in Conrow Creek;
- Potential impacts to wetlands and jurisdictional waters of the U.S. in Conrow Creek;
- State of Montana management concerns for Section 16;
- Potential liabilities to the state of Montana (bonding) for long-term maintenance of a diversion in Section 16; and
- Potential impacts to surface use and existing water rights in Conrow Creek.

II.B.3.a Mine Operations Under the Return Diversion Alternative

Under the Proposed Action, a diversion channel would divert flows from the Sheep Rock Creek drainage northeast into the Conrow Creek drainage. Under the Return Diversion Alternative, Sheep Rock Creek would be diverted around the East Waste Rock Dump and would reconnect with its natural drainage on the south side of the dump (Map II-2). The return diversion would discharge into an unnamed tributary of Sheep Rock Creek about 3,100 feet upstream from where the tributary joins with the main channel of Sheep Rock Creek. The diversion channel would be approximately 7,600 feet long and construction would disturb an area 100 feet wide. A total of 2.5 acres of new disturbance would be created by the channel. (The majority of the total 17.5 acres of disturbance from the channel would occur in previously disturbed areas of the East Waste Rock Dump facility.)

The channel would be sized to accommodate flows equalling the one-half PMF (approximately 976 cfs). The channel would be approximately 40 feet wide and 6 feet deep and would incorporate armoring (i.e., rip-rap) and energy dissipation structures, as necessary, to protect the integrity of the bed and banks. A maintenance road would be constructed along the channel to facilitate inspection, cleaning, and repair. The channel would remain in place following closure and reclamation of the waste rock dump and would be designed to operate in perpetuity. All other aspects of mine operations would remain the same as those described for the Proposed Action.

II.B.3.b Reclamation Under the Return Diversion Alternative

Following construction, the disturbed area no longer needed for operation of the channel would be regraded and seeded to minimize erosion. All other aspects of reclamation would be the same as those described for the Proposed Action. The same 2,506 acres of surface disturbance would be revegetated plus 2.5 acres of additional disturbance for the Sheep Rock Creek diversion structure. This additional surface disturbance would require an additional 2,000 cubic yards of soil for reclamation.

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II.B.4 Divided Dump Alternative

This alternative was formulated to address:

- Impacts that would result from placing acid-generating waste rock in jurisdictional waters of the U.S. located in Sheep Rock Creek;
- Concern over diverting upper Sheep Rock Creek into Conrow Creek and the long-term maintenance of diversion structures; and
- Concern for maintaining the integrity of the existing Sheep Rock Creek drainage channel.

II.B.4.a Mine Operations Under the Divided Dump Alternative

Under the Proposed Action, deposition of waste rock east of Sheep Rock Creek would require that waste rock be placed in the Sheep Rock Creek drainage to buttress the waste rock dumps east of the creek. To prevent the natural flows of Sheep Rock Creek from contacting acid generating waste rock, Sheep Rock Creek would be permanently diverted into the Conrow Creek drainage. The Divided Dump Alternative eliminates the need to divert Sheep Rock Creek by providing alternative options for waste rock disposal. A combination of one or more of several areas could be utilized for waste rock disposal. These are shown on Map II-3. In order to utilize areas in the East Waste Rock Dump facility, a temporary land bridge would be built across Sheep Rock Creek to allow access to waste rock disposal areas east of the creek. The land bridge would be removed at mine closure, allowing the creek to flow in its natural channel. The redesign of the East Waste Rock Dump to accommodate a land bridge would lower the dump from the 5,360-foot level to the 5,200-foot level and reduce the storage capacity of the East Waste Rock Dump by approximately 63 million tons (out of the 82 million tons originally proposed for the East Waste Rock Dump under the Proposed Action). The 63 million tons of waste rock capacity lost from the East Waste Rock Dump would be recovered by utilizing a combination of Areas A, B1, B2, C1, and C2 identified on Map II-3.

Area C1, the C1 Haul Road, and Area C2 are located in and adjacent to the West Waste Rock Dump facility. Areas A, B1, B2, and the land bridge are located in and 0.25 mile east of the East Waste Rock Dump facility. The acreage of new disturbance and total disturbance of each of these areas is presented in Table II-15. Not all of these areas would need to be utilized in order to provide adequate waste rock disposal capacity for mine operations. The agency would select a combination of one or more of these areas, in whole or in part. A minimum and maximum disturbance scenario have been developed in order to provide a range of potential disturbance acreages for purposes of analysis. Disturbance area and surface ownership under the Divided Dump Alternative, for the minimum and maximum disturbance scenarios, are presented in Table II-16. Under the minimum surface disturbance scenario, only Area C2 would be utilized, for a total surface disturbance of 2,743 acres (220 acres less than the Proposed Action). Under the maximum disturbance scenario, Areas A, B2, and the land bridge would be utilized, for a total surface disturbance of 2,936 acres (27 acres less than the Proposed Action). The mine permit boundary would need to be expanded beyond the area described under the Proposed Action in order to accommodate additional disturbance area for Areas C1, C2, B1, and B2. Disturbance occurring above state school trust subsurface lands for the Divided Dump Alternative is shown in Table II-17.

All other aspects of mine operations would remain the same as those described for the Proposed Action.

Land Bridge Construction. The land bridge would be designed to allow Sheep Rock Creek flows to pass through the bridge via a culvert sized to carry the flow from a 100-year, 24-hour storm event. The land bridge would be constructed from the 5,360-foot elevation of the Interim East Waste Rock Dump Complex to the 5,250-foot elevation east of the Sheep Creek drainage. The bridge would be constructed of two materials: subsoil (from the B1 or B2 dump

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Table II-15

Disturbance Area of Waste Rock Dump Facilities Under the Divided Dump Alternative

Facility	New Surface Disturbance	Total Surface Disturbance
West Waste Rock Dump		
Area C1	260	288
C1 Haul Road	38	45
Area C2	139	275
East Waste Rock Dump		
Area A	3	30
Area B1	240	240
Area B2	270	270
Land Bridge	59	72

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Table 5-16

Surface Ownership of Disturbance Area Under the Divided Dump Alternative - Minimum and Maximum Disturbance Scenarios (Acres)[1]

[illegible]	[illegible]	BLM	[illegible]	TOTAL
DISTURBANCE AREA:				
West Waste Rock Dump				
Existing[2]	139	476	0	616
New - Area C1	2	185	73	260
C1 Haul Road	19	19	0	38
Area C2	0	139	0	139
TOTAL - Minimum Scenario	139	617	0	756
Maximum Scenario	139	476	0	616
East Waste Rock Dump				
Existing	263	76	0	339
New - Area A	3	0	0	3
Area B1	87	0	153	240
Area B2	270	0	0	270
Land Bridge	10	40	0	50
TOTAL - Minimum Scenario	229*	76	0	305*
Maximum Scenario	539*	126	0	664*
Buttress				
Existing	166	3	0	169
New	141	0	0	141
Total	303*	3	0	306*
Tailings Area				
Existing	769	2	0	771
New	94	0	0	94
Total	863	2	0	865
Pit				
Existing	275	37	0	312
New	0	0	0	0
Total - Minimum Scenario	290*	37	0	326*
Maximum Scenario	272*	37	0	309*
Plantsite Area				
Existing	81	17	0	98
New	33	0	0	33
Total	170*	17	0	187*
Roads				
Existing	31	0	0	31
New	0	0	0	0
Total	29*	0	0	29*
[illegible]	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]	0 0 0	[illegible] [illegible] [illegible]

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Table 8-16 (Continued)

[illegible]	[illegible] (Acres)	[illegible]	[illegible]	[illegible]
[illegible]				
Existing	[illegible]	[illegible]	0	[illegible]
New	[illegible]	[illegible]	0	[illegible]
Total	[illegible]	[illegible]	0	[illegible]

[a] Under this alternative, the agency may select a combination of one or more of the alternative dump areas, in whole or in part, for waste rock disposal. The minimum and maximum scenarios were developed to provide a range of disturbance acreages for purposes of analysis. The minimum scenario utilizes Area C2 for waste rock disposal. The maximum scenario utilizes Areas A, B2, and the land bridge for waste rock disposal.

[b] Existing is defined as occurring through the *Interim Dump Plan*.

Note: Totals may not add due to rounding.

* Totals do not add due to overlap of facilities in the following areas:

- The plantsite area would expand into 10 acres of previously disturbed land in the East Waste Rock Dump, and 46 acres of previously disturbed land in the buttress area.
- The pit would expand into 24 acres of previously disturbed land in the East Waste Rock Dump.
- Area A would expand into 27 acres of previously disturbed land in the pit.
- The buttress would expand into 2 acres of previously disturbed land in the roads area.

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Table 5-17

Disturbance Occurring Above State School Trust Subsurface Lands
Divided Dump Alternative[1]

Mine Facility	[illegible]	[illegible]	[illegible]	[illegible]
West Waste Rock Dump				
Area C1	S28	51	51	0
C1 Construction Buffer	S28	22	0	22
East Waste Rock Dump				
Existing Dump and Haul Roads	S17, S20	171	171	0
Area B1	S16, S21	200	200	0
B1 Construction Buffer	S16, S21	33	0	33
Area B2	S21	221	221	0
B2 Construction Buffer	S21	47	0	47
Land Bridge	S20, S21	5	5	0
Land Bridge Construction Buffer	S20, S21	5	0	5
Buttress				
Buttress and Haul Roads	S20	2	2	0
Construction Buffer	S20	0	0	0
Tailings Area				
Tailings	S28, S33	112	112	0
Seeded Area	S28, S33	6	0	6
Miscellaneous Disturbance	S28, S33	120	0	120
Plantsite Area				
Miscellaneous Disturbance	S20	23	0	23
TOTAL - Minimum Disturbance Scenario		440	[illegible]	[illegible]
Maximum Disturbance Scenario		720	[illegible]	[illegible]

[1] Under this alternative, the agency may select a combination of one or more of the alternative dump areas, in whole or in part, for waste rock disposal. The minimum and maximum scenarios were developed to provide a range of disturbance acreages for purposes of analysis. The minimum scenario utilizes Area C2 for waste rock disposal. The maximum scenario utilizes Areas A, B2, and the land bridge for waste rock disposal.

Note: Totals may not add due to rounding.

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location) and waste material. The first phase of construction would involve placing a culvert in the stream channel. The galvanized steel culvert would extend a total length of 1,500 feet.

The second phase of construction would involve placing a "pad" of neutral material over the culvert. The most readily available material is the subsoil below the B1 and B2 Areas. This material could be used to support the foundation of the land bridge after the topsoil has been stripped and the culvert has been put in place. The "pad" of subsoil would act as a neutral foundation to the structure. If water ponds behind the culvert, it would only come in contact with this neutral material. Because the subsoil would be coming from Area B1 or B2, the "pad" would be constructed from east to west. The "pad" would extend 20 feet above the top of the culvert and consist of approximately 1 million tons of material (approximately 600,000 cubic yards). The pad of the land bridge would take approximately 100 days to construct assuming that 10,000 tons of material is hauled, placed, and compacted daily.

The third phase of construction would involve placing waste material over the subsoil "pad." This waste would be end-dumped from the interim dump to the new dump. Approximately 11 million tons of waste would be placed above the subsoil to construct the land bridge. The final phase of construction would include several activities: final compaction of the land bridge, construction of berms along the bridge edges, and final road construction of the dumping platforms in Areas B1 or B2.

At the end of mine life, the land bridge would be torn down and the material off-loaded. As part of tear-down of the bridge, material would be off-loaded from the base of the structure. This off-loading would disturb areas of the creek that have not previously been disturbed. GSM estimates that approximately 1,750 feet of the 2,500-foot channel length would be temporarily disturbed by the land bridge and associated activities. This would result in a total disturbance of 0.4 acre of jurisdictional Waters of the United States (WUS), including 0.3 acre for the land bridge and 0.1 acre for roads and other activities.

Waste Rock Disposal Areas. Potential waste rock storage Areas A, B1, B2, C1, and C2 have been evaluated for storage capacity to replace the 63 million tons of waste rock storage capacity that would be lost from the East Waste Rock Dump. The total capacity analyzed equals 309 million tons. A combination of one or more of these areas may be fully or partially permitted based on the analysis and decision.

- Area A. Area A is north and west of the existing northeast dump complex. Approximately 5 million tons of waste rock material could be placed in this area, assuming a 2:1 slope. A waste rock dump in this area may pose a stability problem due to potentially unstable foundation conditions on the north and east. To the south, the dump is confined by the edge of the pit highwall. To the east, the dump is confined by the East Waste Rock Dump. At a 2:1 final slope, the dump could not be built higher in elevation up the drainage. For these reasons, waste rock storage in this area could not be expanded beyond its 5 million ton design capacity. No WUS exist in this area.

- Area B1 and B2. Area B1 has a total capacity of 85 million tons. The waste rock dump in this area has been designed with a 2:1 slope and a 3:1 slope buffer area. The dump would be constructed mostly on limestone bedrock, which should provide a highly reliable foundation. Area B1 would utilize state school trust surface land within Section 16 and GSM surface land within Section 21 (the mineral estate belongs to the state school trust in this Section). The elevation of the dump would be 5,250 feet. By using the Conrow Creek drainage divide as a dumping control rather than the Section line (between Sections 16 and 21), disturbed acreage would be minimized and the dump would be easier to construct. Because Areas B1 and B2 lie on either side of this ridgeline, no buffer areas are indicated for the south portion of Area B1 or the north portion of Area B2. Soil stripping could not begin on the B1 location until the EIS is completed; the dump space in this area could not be utilized until 3 months following.

Alternative dump locations for east-bound waste rock material may be required until the land bridge and dumping platforms could be constructed. Approximately 1.1 acres of WUS exist in Area B1.

Area B2 (located entirely within Section 21) has a total capacity of 65 million tons. The dump in this area has been designed with a 2:1 slope and a 3:1 slope buffer area. This dump also is founded primarily on limestone bedrock, which should not present stability concerns. Area B2 has been designed not to infringe upon state surface land in Section 16; the waste rock dump is located entirely on GSM surface land within Section 21. The elevation of the dump is 5,280 feet to the west and 5,400 feet to the east and south. As with area B1, there are construction/timing limitations with area B2. Because soil stripping could not begin on the B2 location until the EIS is completed, and the dump space could not be utilized until 3 months following, alternative dump locations for east-bound waste rock material may be required until the land bridge and dumping platforms could be constructed. Approximately 0.5 acre of WUS exist in Area B2.

In addition, construction of the land bridge necessary to access Areas B1 and B2 would require crossing Sheep Rock Creek with equipment before the land bridge is constructed to obtain the subsoil necessary for construction of the land bridge (GSM plans to construct the base of this land bridge with subsoil from the B2 dump complex). The only existing access that GSM has to the B2 dump complex is an unimproved road below the proposed bridge location. Approximately 0.3 acre of WUS exist in the land bridge area. Construction of an improved access road would disturb approximately 0.1 additional acre of jurisdictional WUS. This disturbance (0.4 acre total) is considered temporary, as the land bridge would be removed following mine closure.

- Areas C1 and C2 (West Side). Area C1 has a total capacity of 80 million tons with no foreseeable stability concerns based on available information. The dump has been designed with a 2:1 slope, and would utilize a portion of state school trust surface land in Section 36. Utilizing this area for waste rock disposal would require construction of a haul road above the mill, extending at the 5,300-foot elevation around the south dump. The new haul road would create a 250-foot cut on the hillside. The haul route would extend 11,880 feet (assuming an average haul). Design of the haul road at a 5,300-foot elevation dictates that the road must cross two dumps: the unreclaimed south dump and the southern end of the West Waste Rock Dump. Construction of the haul road would increase final reclamation requirements by approximately 38 acres and affect 0.1 acre of WUS. A comprehensive erosion control system would be required to ensure that no material would slough onto the haul roads. Concurrent reclamation that has been initiated on the West Waste Rock Dump would need to be discontinued if additional materials were deposited on the West Waste Rock Dump. Approximately 0.8 acre of WUS exist in Area C1.

  Area C2 has a total capacity of 104,250,000 tons with no foreseeable stability concerns based on available information. The dump has been designed with a 2:1 slope. Utilizing this area for waste rock disposal would require that the pit be redesigned to accommodate westbound haul traffic. Currently, the pit design will not allow material below the 5,580-foot bench to be hauled west. The access road to the top of the pit at this time only allows for single-lane traffic; therefore, the pit would have to be redesigned to account for an increased 120-foot wide haul road width. This revision of the pit design would reduce otherwise recoverable ore reserves at the pit bottom by approximately 6.6 percent. Approximately 0.7 acre of WUS exist in Area C2.

II.B.4.b Reclamation Under the Divided Dump Alternative

Reclamation plans under the Divided Dump Alternative would be the same as those described for the Proposed Action Alternative, except that the total disturbance area requiring reclamation would be different. The estimated soil and neutral capping requirements for reclamation under the Divided Dump Alternative (for both the minimum and maximum disturbance scenarios) are shown in Table II-18. The land bridge is considered a temporary structure, as it would be completely removed following mine closure. Therefore, no neutral capping materials would be required for reclamation of the land bridge. Total disturbance and areas revegetated would depend on which areas are selected for waste rock disposal. Approximately 264 acres would not be revegetated, including 235 acres in the pit and 31 acres of roads.

Table II-18

Estimated Soil and Neutral Capping Requirements for Reclamation Under the Divided Dump Alternative[1]

Mine Facility	Disturbance Area (Acres)	Sulfide Covered (Acres)	Non-Sulfide Covered (Acres)	Neutral Capping Requirements (yd^3)	Soil Requirements (yd^3)
West Waste Rock Dump					
Existing West Waste Rock Dump - Total	616	415	201	1,425,700	1,237,500
Area C1 Dump	231				
C1 Construction Buffer	57				
C1 Haul Road	45				
Area C2 Dump	183				
C2 Construction Buffer	92				
TOTAL - Minimum Disturbance Scenario	755*	532	223	1,849,700	1,583,800
Maximum Disturbance Scenario	616	415	201	1,425,700	1,237,500
East Waste Rock Dump					
Existing East Waste Rock Dump - Total	339	312	27	1,059,300	1,081,400
Area A Dump	30				
Area B1 Dump	201				
B1 Construction Buffer	39				
Area B2 Dump	221				
B2 Construction Buffer	49				
Land Bridge Dump[2]	50				
Land Bridge Construction Buffer	22				
TOTAL - Minimum Disturbance Scenario	306*	306	0	1,036,100	1,036,100
Maximum Disturbance Scenario	664*	597	67	1,962,400	1,866,400
Buttress					
TOTAL	266	217	49	720,000	759,300
Tailings Area					
TOTAL	865	349	516	1,128,800	1,443,800
Pit					
TOTAL - Minimum Disturbance Scenario	336	254	82	60,300	124,800
Maximum Disturbance Scenario	309*	254	55	60,300	102,800

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Table II-18 (Continued)

Mine Facility	Disturbance Area (Acres)	Sulfide Covered (Acres)	Non-Sulfide Covered (Acres)	Neutral Capping Requirements (yd^3)	Soil Requirements (yd^3)
Plantsite Area TOTAL	187	35	152	112,300	227,900
Roads Outside Disturbance Boundary TOTAL	29	0	29	0	0
TOTAL - Minimum Disturbance Scenario Maximum Disturbance Scenario	2,748 2,938	[illegible] [illegible]	1,651 [illegible]	[illegible] [illegible]	[illegible] [illegible]
TOTAL AVAILABLE[3] - Minimum Disturbance Scenario Maximum Disturbance Scenario				6,165,700 6,165,700	[illegible] [illegible]

(For a further breakdown of types of disturbance within each facility area, see Table II-14 for reclamation requirements under the Proposed Action.)

[1] Under this alternative, the agency may select a combination of one or more of the alternative dump areas, in whole or in part, for waste rock disposal. The minimum and maximum scenarios were developed to provide a range of disturbance acreages for purposes of analysis. The minimum scenario utilizes Area C2 for waste rock disposal. The maximum scenario utilizes Areas A, B2, and the land bridge for waste rock disposal.

[2] The land bridge is a temporary structure that would be completely removed following mine closure. Therefore, no neutral capping materials would be required for reclamation of this area.

[3] Any shortfalls of either topsoil or oxide rock for neutral capping will be provided from borrow areas in one of the following locations: (a) the tailings dam miscellaneous area; (b) the buttress miscellaneous area; or (c) the plantsite miscellaneous area.

Note: Totals may not add due to rounding.

- Totals do not add due to overlap of facilities in the following areas:
  - Area C2 dump and construction buffer contain 136 acres of overlap with the West Waste Rock Dump.
  - The plant site area would expand into 10 acres of previously disturbed land in the East Waste Rock Dump.
  - The pit would expand into 24 acres of previously disturbed land in the East Waste Rock Dump.
  - The land bridge dump and construction buffer contain 13 acres of overlap with the East Waste Rock Dump.
  - Area A would expand into 27 acres of previously disturbed land in the pit.

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II.B.5 3:1 Slope Alternative

This alternative was formulated to address concerns raised in the Court Order and Settlement Agreement regarding the feasibility of reclaiming 2:1 waste rock dump slopes.

II.B.5.a Mine Operations Under the 3:1 Slope Alternative

All aspects of mine operations would be the same as the Proposed Action, except that the ultimate disturbance area of the East and West Waste Rock Dumps would be slightly larger. Total surface disturbance under the 3:1 Slope Alternative would be 3,078 acres (114 acres more than the Proposed Action). The total new disturbance area would then be 741 acres, including 539 acres of GSM-owned land, 167 acres of BLM-administered land, and 35 acres of state land (see Table II-19). The permit boundary area would be the same as for the Proposed Action. Total surface disturbance occurring above state school trust subsurface lands under the 3:1 Slope Alternative would include 466 acres of sulfide-covered disturbance and 275 acres of non-sulfide covered disturbance, for a total of 741 acres (see Table II-20).

II.B.5.b Reclamation Under the 3:1 Slope Alternative

Under the Proposed Action, waste rock dump slopes would be reclaimed at a combination of grades ranging from 2:1 to 3:1, depending on location. Under the 3:1 Slope Alternative, additional slopes would be graded to 3:1 prior to revegetation. Areas that would change from 2:1 to 3:1 would be located on the East, South, and West Waste Rock Dumps. By reducing slopes to 3:1, a larger area at the toe of the dumps would be covered by waste rock when the slopes are graded. The East and West Waste Rock Dumps (including construction buffers) would be 92 acres and 22 acres larger, respectively, than the dumps under the Proposed Action. Map II-4 shows the ultimate disturbance boundary for the 3:1 slopes. Where grading to 3:1 would greatly expand impacts, such as filling a drainage, or covering mine facilities, final slopes would be graded to the least slope possible between 2:1 and 3:1. All other aspects of reclamation would remain the same as those described for the Proposed Action.

The additional 114 acres of surface disturbance under this alternative would be reclaimed according to procedures outline for waste rock dump reclamation under the Proposed Action. The area not revegetated would be the same as for the Proposed Action. Estimated neutral capping and soil requirements, by mine facility area, for reclamation under the 3:1 Slope Alternative are shown in Table II-21. The total estimated neutral capping volume required is 5,514,200 cubic yards. The total estimated volume of neutral capping material available is 6,195,700 cubic yards (same as the Proposed Action). The total estimated soil volume required is 5,924,500 cubic yards. The total estimated soil volume available is 6,531,500 cubic yards.

Table 5-10

Surface Ownership of Disturbance Area Under the 3:1 Slope Alternative (Acres)

[illegible]	[illegible]	[illegible]	[illegible]	
DISTURBANCE AREA:				
West Waste Rock Dump Existing[1] New Total	138 0 138	478 92 570	0 0 0	616 92 708
East Waste Rock Dump Existing New Total	263 271 505*	76 75 151	0 35 35	339 381 691*
Buttress Existing New Total	166 141 263*	3 0 3	0 0 0	169 141 266*
Tailings Area Existing New Total	769 94 863	2 0 2	0 0 0	771 94 865
Pit Existing New Total	275 0 299*	37 0 37	0 0 0	312 0 336*
Plantsite Area Existing New Total	81 33 170*	17 0 17	0 0 0	98 33 187*
Roads Existing New Total	31 0 24*	0 0 0	0 0 0	31 0 24*
TOTAL DISTURBANCE AREA Existing New Total	[illegible] [illegible] [illegible]	[illegible] 167 780	0 35 35	[illegible] 741 [illegible]

[1]Existing is defined as occurring through the *Interim Dump Plan*.

Note: Totals may not add due to rounding.

* Totals do not add due to overlap of facilities in the following areas:
- The East Waste Rock Dump would expand into 5 acres of previously disturbed land in the roads area.
- The plantsite area would expand into 10 acres of previously disturbed land in the East Waste Rock Dump, and 46 acres of previously disturbed land in the buttress area.
- The pit would expand into 24 acres of previously disturbed land in the East Waste Rock Dump.
- The buttress would expand into 2 acres of previously disturbed land in the roads area.

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Table 5-30

Disturbance Occurring Above State School Trust Subsurface Lands
2:1 Slope Alternative

[illegible]	State School Trust Subsurface Sections Affected	Surface Disturbance (Acres)	Surface Covered (Acres)	[illegible]
East Waste Rock Dump				
Dump and Haul Roads	S17, S20, S21	352	352	0
Construction Buffer	S16, S17, S20, S21	61	0	61
Sheep Creek Diversion	S16, S20, S21	22	0	22
Miscellaneous Disturbance	S16, S17, S20, S21	30	0	30
Buttress				
Buttress and Haul Roads	S20	2	2	0
Construction Buffer	S20	6	0	6
Tailings Area				
Tailings	S28, S32	112	112	0
Seeded Area	S28, S33	6	0	6
Miscellaneous Disturbance	S28, S33	120	0	120
Plantsite Area				
Miscellaneous Disturbance	S20	23	0	23
TOTAL		[illegible]	466	[illegible]

Note: Totals may not add due to rounding.

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Table 5-21

Estimated Soil and Neutral Capping Requirements for Reclamation Under the 3:1 Slope Alternative

Mine Facility	Disturbance Area (Acres)	Sulfide Covered (Acres)	Non-Sulfide Covered (Acres)	Neutral Capping Requirements (yd³)	Soil Requirements (yd³)
West Waste Rock Dump					
Dump and Haul Roads	513	513	0	1,722,200	1,291,600
Construction Buffer	92	0	92	0	74,200
Miscellaneous	30	0	30	0	20,300
Undisturbed or Seeded and Reclaimed	65	0	65	0	0
TOTAL	700	513	187	1,722,200	1,408,400
East Waste Rock Dump					
Dump and Haul Roads	532	532	0	1,773,000	1,773,000
Construction Buffer	135	0	135	0	108,700
Miscellaneous	25	0	25	0	20,300
TOTAL	692	532	160	1,773,000	1,902,000
Buttress					
Buttress and Haul Roads	217	217	0	720,000	720,000
Construction Buffer	47	0	47	0	37,600
Miscellaneous	2	0	2	0	1,400
TOTAL	266	217	49	720,000	759,000
Tailings Area					
Tailings	340	340	0	1,125,000	1,125,000
Miscellaneous	394	0	394	0	317,700
Undisturbed or Seeded and Reclaimed	122	0	122	0	0
TOTAL	856	340	516	1,125,000	1,443,000
Pit					
Roads and Benches	19	19	0	60,300	60,300
Highwall[1]	235	235	0	0	0
Miscellaneous	80	0	80	0	64,500
Undisturbed or Seeded and Reclaimed	2	0	2	0	0
TOTAL	336	254	82	60,300	124,800

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Table II-21 (Continued)

Mine Facility	Disturbance Area (Acres)	Sulfide Covered (Acres)	Non-Sulfide Covered (Acres)	Neutral Capping Requirements (yd³)	Soil Requirements (yd³)
Plantsite Area					
Plantsite	35	35	0	112,300	112,300
Miscellaneous	143	0	143	0	115,800
Undisturbed or Seeded and Reclaimed	9	0	9	0	0
TOTAL	187	35	152	112,300	227,900
Roads Outside Disturbance Boundary	24	0	24	0	0
TOTAL	3,079	1,899	1,179	8,514,300	5,894,900
TOTAL AVAILABLE				8,165,700	6,091,000

[1] Pit "Highwall" includes all areas within the pit that would not be reseeded or revegetated due to steep slopes or inaccessibility.

Note: Totals may not add due to rounding.

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II.B.6 No Pit Pond Alternative

This alternative was formulated to address potential impacts to wildlife, especially waterfowl and raptors, that could result from allowing poor quality water to pond in the pit bottom.

II.B.6.a Mine Operations Under the No Pit Pond Alternative

All aspects of mine operations would be the same as the Proposed Action. The disturbance and permit boundary areas would be the same as those described under the Proposed Action.

II.B.6.b Reclamation Under the No Pit Pond Alternative

The Proposed Action allows the pit to partially fill with surface water and groundwater following the end of mining. Water would be pumped from the pond in the pit bottom to the water treatment facility as needed to maintain the pit as a hydrologic sink, and to prevent poor quality groundwater from leaving the pit area. Under the No Pit Pond Alternative, final design for the pit at the completion of mining would provide for an underground sump to collect the surface water and groundwater that enters the pit. Water collected in the sump would be pumped to the permanent water treatment plant, as needed. No water would be allowed to pond in the pit bottom.

In order to provide safe access to the floor of the pit for periodic maintenance of the dewatering system, the pit would be partially backfilled with waste rock to the 4,800-foot elevation (approximately 100 feet). There would be 712,750 tons of backfill. A cross-section of the pit under the No Pit Pond Alternative is shown in Figure II-3. This partial backfilling of the pit would allow creation of a flat working area of approximately 400 feet by 800 feet. Additional protection can be provided by building one or more berms around the perimeter of the working area to trap incidental rocks that may fall from the high wall. If necessary, the ramp access leading down to the working area from the 4,875-foot elevation can be widened by extending the ramp to the south, over a portion of the 4,800-foot area, and away from the highwall toe.

The precipitation that falls within the pit perimeter under the No Pit Pond Alternative would infiltrate into the fractured high wall and coarse rock-filled bottom. The groundwater dewatering system needed to keep the pit dry would maintain the groundwater level at just below the 4,800-foot elevation. Dewatering to the 4,800-foot level would require perpetual removal of approximately 102 gpm. GSM would continue to monitor spring flows monthly during operations and through closure.

One possible approach to dewatering is to use inclined (near horizontal) drains that are drilled from the floor of the pit into target zones behind the pit highwalls. The horizontal drains could be constructed by drilling 4-inch to 6-inch diameter boreholes, into which, 2-inch to 4-inch diameter PVC pipes would be inserted. The PVC pipes would be perforated within the targeted dewatering zones, and then sealed off from the remainder of the open boreholes to minimize the formation of ARD. The drains would be used in combination with the vertical wells, but would not require individual pumps. Instead, the discharge lines would be manifolded into a common conveyance that reports to a collection/pumping station. Depending on water quality, the discharge would either be routed by pipeline to the permanent water treatment plant or directly to a land application disposal area away from the pit.

Estimated reclamation requirements under this alternative would be the same as under the Proposed Action except that the pit highwall area would be 7 acres less, and the pit roads and benches area 7 acres greater. Consequently, total sulfide-covered acres would be 7 acres less (1,767 acres) and total non-sulfide covered acres would be 7 acres greater (1,197 acres). The area not revegetated would be the same as for the Proposed Action. Total estimated neutral capping and soil volume requirements would include an additional 21,900 cubic yards of each over the Proposed Action amounts, for a total of 5,162,900 cubic yards of neutral capping material, and 5,844,300 cubic yards of soil. Total estimated volumes available would be the same as the Proposed Action.

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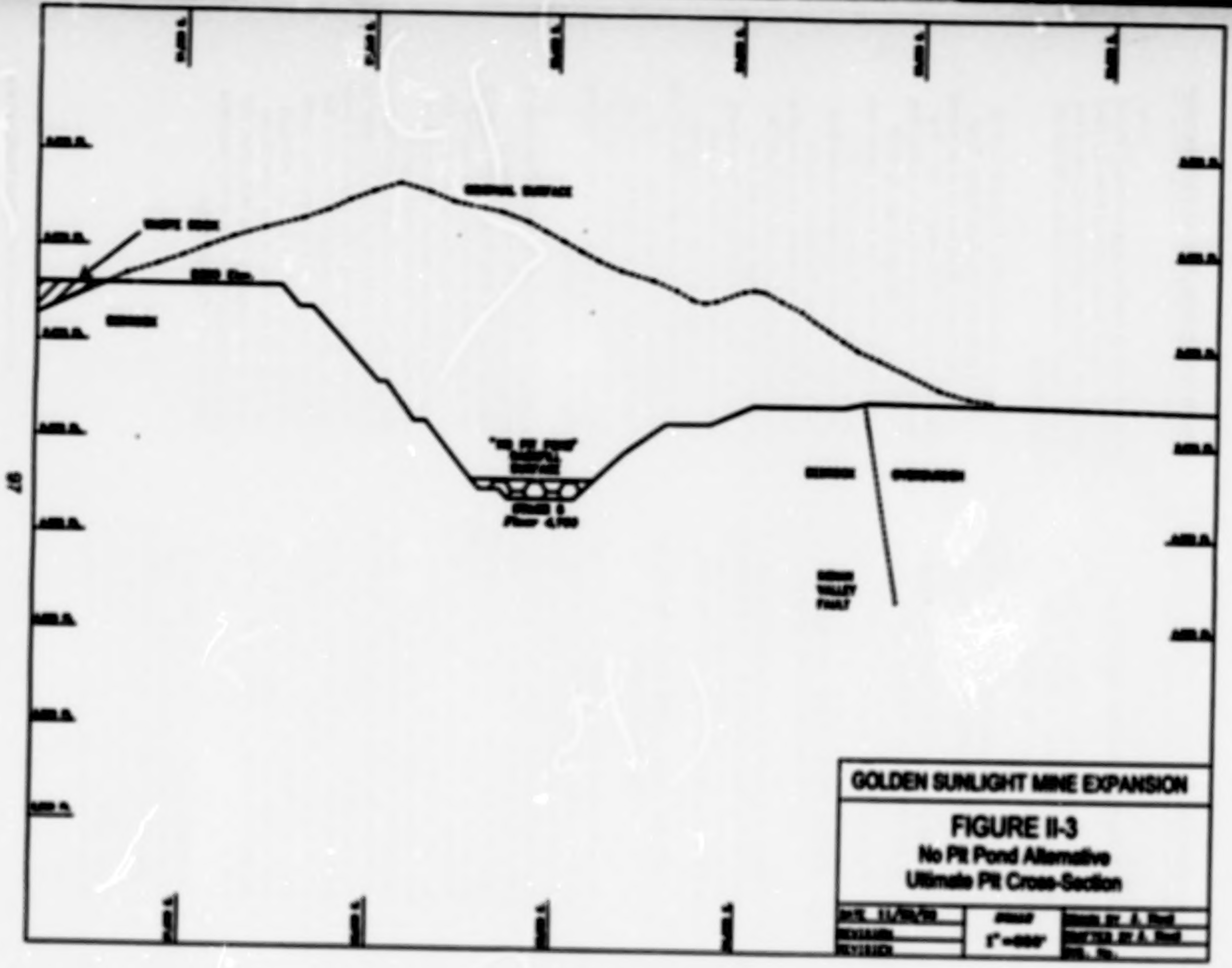

GOLDEN SUNLIGHT MINE EXPANSION

FIGURE II-3
No Pit Pond Alternative
Ultimate Pit Cross-Section

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II.B.7 Partial Backfill Alternative

This alternative was formulated to address concerns raised in the Court Order and Settlement Agreement regarding:

- Pit reclamation feasibility under the Montana Metal Mine Reclamation Act;
- Reclamation of disturbed lands as required by the Montana Constitution; and
- Perpetual Water Treatment.

II.B.7.a Mine Operations Under the Partial Backfill Alternative

All aspects of mine operations would be the same as the Proposed Action. The disturbance and permit boundary areas would be the same as those described under the Proposed Action.

II.B.7.b Reclamation Under the Partial Backfill Alternative

This alternative involves partial backfilling of the pit during reclamation. Material to backfill the pit would be obtained from the East and West Waste Rock Dumps. Under the Proposed Action, approximately 19 acres of pit benches would be capped with oxidized waste rock and soil, and revegetated. Under the Partial Backfill Alternative, all acid-producing rock within the pit (approximately 254 acres) would be capped with oxidized waste rock and soil, and revegetated. A cross-section of the ultimate pit under this alternative is presented in Figure II-4. The area revegetated would increase by 236 acres over the Proposed Action, for a total of 2,840 acres revegetated. (Only 24 acres of roads areas would not be revegetated.) All other aspects of mine reclamation would remain the same as those described for the Proposed Action.

Backfilling the Pit. Conceptually, backfilling the pit to a daylight level and reclaiming the upper pit slopes would consist of two activities: 1) hauling approximately 52 to 55 million tons of waste material from the East Waste Rock Dump to the pit and beginning to cap the highwall at a 2:1 slope; and 2) hauling approximately 30.8 to 33 million tons of waste material from the West Waste Rock Dump to complete capping of the highwall. Each of these activities is discussed in detail below.

- Activity 1. Hauling 52 to 55 million tons of waste material from the East Waste Rock Dump first involves filling the pit at an overall 3.8 percent grade from west to east. The western-most elevation would be 5,350 feet, and the key cut (eastern-most) elevation would be 5,200 feet. The overall grade was calculated using a fill slope length of 3,807 feet. Hauling material from the East Waste Rock Dump also would involve capping the lower highwall. Once the pit is backfilled to 5,200 feet, material would be end-dumped from both the 5,400 and 5,600 elevations. End-dumping from these elevations would cap the lower highwall. A 2:1 ultimate highwall slope was assumed. This waste material would come entirely from the 5,620- and 5,500-foot benches of the East Waste Rock Dump (areas near the pit), thus reducing the area covered by the East Waste Rock Dump by 82 acres (on GSM and BLM-administered land).
- Activity 2. The second hauling effort involves transporting 30.8 to 33 million tons of material from the West Waste Rock Dump to the upper portion of the pit. This material would be used to cap the highwall from the 5,600-foot elevation upward. Placement of waste material in the pit would involve end-dumping from the pit crest, and then contouring to provide an overall 2:1 slope on the highwall of the pit. The sources of waste material would be the 6,020-foot bench, the 5,870-foot bench, and the 5,850-foot bench of the West Waste Rock Dump. Although the height of the West Waste Rock Dump would be decreased by this alternative, the disturbed area covered would not decrease relative to the Proposed Action.

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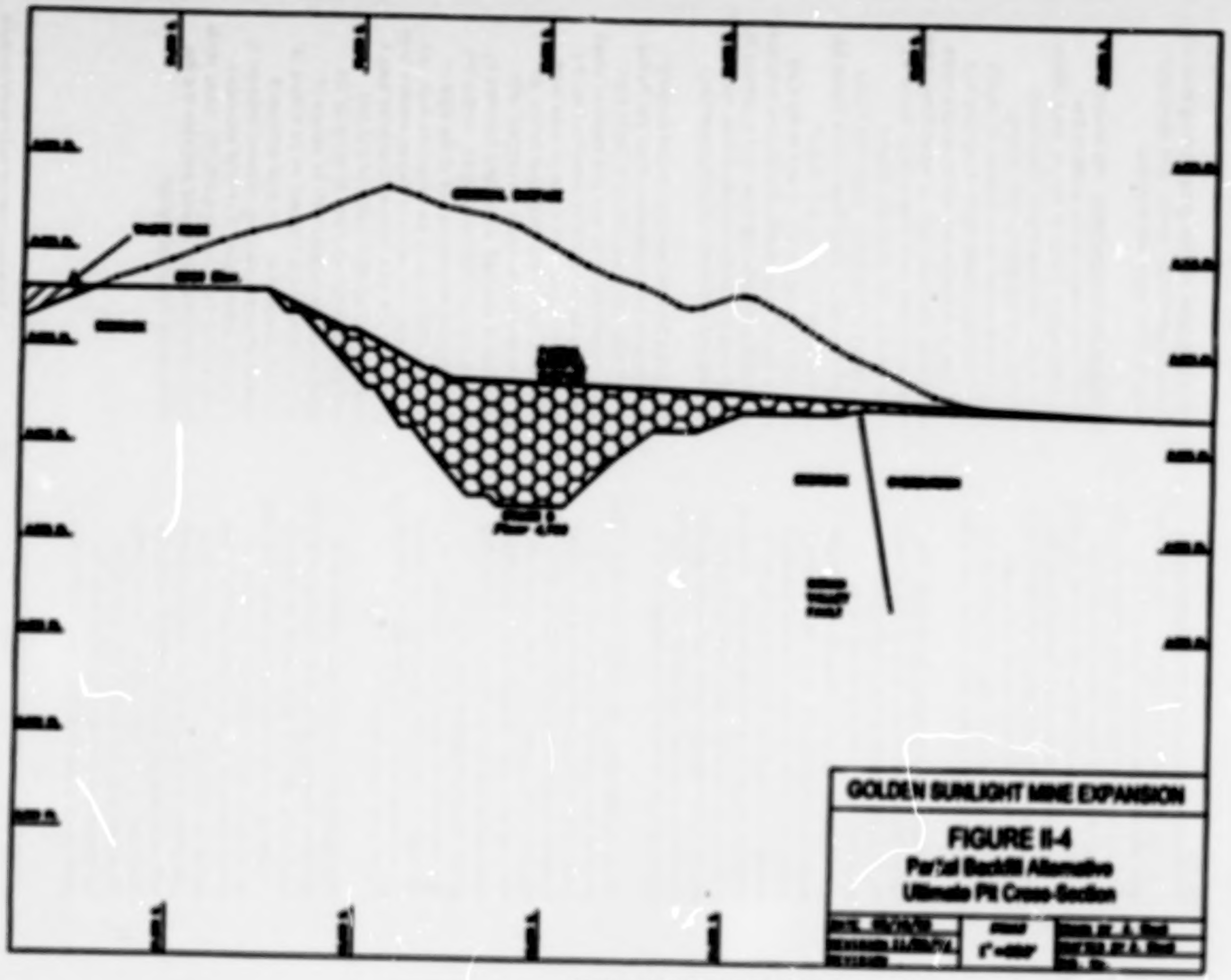

GOLDEN SUNLIGHT MINE EXPANSION

FIGURE II-4
Partial Backfill Alternative
Ultimate Pit Cross-Section

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The stockpile sources for the oxidized waste rock cap are Oxide Stockpiles #7 and #9 (see 1994 GSM Annual Report Oxide and Soil Location Map) on the east side, which would be used to cap pit slopes below the 5,650-foot elevation. Oxide stockpiles #1 and #2 (located on top of West Waste Rock Dump) would be used to cap pit slopes between elevations 5,650 and 5,850 feet. Topsoil would come from stockpiles #6 - #11 on the east side and from stockpiles #5, #19, and #21 on the west side.

__Pit Dewatering and Water Treatment.__ The Partial Backfill Alternative is expected to reduce the amount of surface water recharge that potentially has to be treated (by up to approximately 52 gpm) because storm water could be routed directly off of the reclaimed slopes out of the pit area. It would therefore reduce the amount of dewatering required to maintain the pit as a hydrologic sink. However, a pit dewatering and water treatment system would still be needed under the Partial Backfill Alternative to prevent groundwater from flowing from the rock beneath the reclaimed pit area.

Using Hydrometrics, Inc. (1995) modeling, GSM projects that dewatering to an elevation of approximately 5,250 feet (the point of contact between bedrock and colluvium) would be required in the partially backfilled pit to maintain the area as a sink. Based on the estimated pit dewatering rate for the Proposed Action, this would require perpetual pumping of approximately 47 gpm of groundwater. The geologic cross-section showing the projected groundwater level in the ultimate pit is shown as Figure 3 of Hydrometrics, Inc (1995).

The dewatering system would consist of a series of dewatering wells constructed along the floor of the pit. The wells would be drilled to depths below the 5,050-foot elevation, and have an 8-inch to 10-inch diameter borehole. A 6-inch diameter polyvinyl chloride (PVC) liner would be inserted in each borehole to allow placement of a submersible pump equipped with electronic sensors to maintain optimum drawdown of the water table. The discharge lines would be manifolded into a common conveyance and routed by pipeline to the permanent water treatment plant prior to being discharged back into the ground, away from the pit area in percolation ponds, land application areas, or other approved outlets.

__Reclamation Requirements.__ Reclamation requirements would be the same as the Proposed Action except in the pit, West Waste Rock Dump, and East Waste Rock Dump. Differences in soil and neutral capping requirements would be as follows: 1) slightly less in the West Waste Rock Dump due to a reduction in sloped areas, which require more reclamation materials than flat areas (Under the Proposed Action, West Waste Rock Dump flat disturbance is 181 acres and sloped disturbance is 234 acres. Under the Partial Backfill Alternative, West Waste Rock Dump flat disturbance is 197 acres and sloped disturbance is 218 acres); 2) less in the East Waste Rock Dump, due to the 82-acre reduction in the dump disturbance area; and 3) greater in the pit area due to the increased area requiring capping and soil cover following backfilling.

The total estimated soil and neutral capping requirements for reclamation under the Partial Backfill Alternative are shown in Table 8-22. Depth specifications for soil and oxidized waste rock would be the same as described for the Proposed Action except in the pit area (see Table 8-7). Under the Proposed Action, pit benches and roads would be capped with 24 inches of oxidized waste rock followed by 24 inches of soil and revegetated. Under the Partial Backfill Alternative, out of the total of 254 backfilled acres to be reclaimed in the pit, approximately 187 acres of sloped areas would be capped with 28.8 inches of oxidized waste rock followed by 28.8 inches of soil and revegetated; approximately 67 acres of flat areas would be capped with 24 inches of oxidized waste rock followed by 24 inches of soil and revegetated. The total estimated volume of neutral capping material required is 5,882,200 cubic yards. The total estimated volume of soil required is 6,246,100 cubic yards. The total estimated volumes available are the same as the Proposed Action.

Table II-22

Estimated Soil and Neutral Capping Requirements for Reclamation Under the Partial Backfill Alternative

Mine Facility	Disturbance Area (Acres)	Sulfide Covered (Acres)	Non-Sulfide Covered (Acres)	Neutral Capping Requirements (yd^3)	Soil Requirements (yd^3)
West Waste Rock Dump					
Dump and Haul Roads	415	415	0	1,419,800	1,123,500
Construction Buffer	98	0	98	0	79,000
Miscellaneous	38	0	38	0	30,300
Undisturbed or Seeded and Reclaimed	66	0	66	0	0
TOTAL	**616**	**415**	**201**	**1,419,800**	**1,232,900**
East Waste Rock Dump					
Dump and Haul Roads	423	423	0	1,424,600	1,424,600
Construction Buffer	113	0	113	0	91,200
Miscellaneous	134	0	134	0	111,600
TOTAL	**670**	**423**	**247**	**1,424,600**	**1,627,300**
Buttress					
Buttress and Haul Roads	217	217	0	720,000	720,000
Construction Buffer	47	0	47	0	37,900
Miscellaneous	2	0	2	0	1,400
TOTAL	**266**	**217**	**49**	**720,000**	**759,300**
Tailings Area					
Tailings	349	349	0	1,125,800	1,125,800
Miscellaneous	394	0	394	0	317,700
Undisturbed or Seeded and Reclaimed	122	0	122	0	0
TOTAL	**865**	**349**	**516**	**1,125,800**	**1,443,500**

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Table II-22 (Continued)

Mine Facility	Disturbance Area (Acres)	Sulfide Covered (Acres)	Non-Sulfide Covered (Acres)	Neutral Capping Requirements (yd^3)	Soil Requirements (yd^3)
Pit					
Roads and Benches	0	0	0	0	0
Backfilled Area	254	254	0	889,800	889,800
Miscellaneous	80	0	80	0	64,500
Undisturbed or Seeded and Reclaimed	2	0	2	0	0
TOTAL	336	254	82	889,800	954,200
Plantsite Area					
Plantsite	35	35	0	112,300	112,300
Miscellaneous	143	0	143	0	115,600
Undisturbed or Seeded and Reclaimed	9	0	9	0	0
TOTAL	187	35	152	112,300	227,900
Roads Outside Disturbance Boundary	24	0	24	0	0
TOTAL	2,984	1,693	1,272	5,882,200	6,245,100
TOTAL AVAILABLE				6,195,700	6,375,300

Note: Totals may not add due to rounding.

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II.C ALTERNATIVES EVALUATED BUT ELIMINATED FROM DETAILED ANALYSIS

II.C.1 Overdrain Alternative

This alternative was formulated to address:

- Potential long-term impacts to water quality in Conrow Creek and the Boulder River watershed from increased discharge volumes in Conrow Creek;
- Potential long-term impacts to wetlands and jurisdictional waters of the U.S. in Conrow Creek;
- State of Montana management concerns for Section 16;
- Potential liabilities to the state of Montana (bonding) for long-term maintenance of a diversion in Section 16; and
- Potential long-term impacts to surface use and existing water rights in Conrow Creek.

Under the Overdrain Alternative, Sheep Rock Creek initially would be diverted into an unnamed tributary of Conrow Creek as described for the Proposed Action. The East Waste Rock Dump would then be constructed in the Sheep Rock Creek drainage. Following completion of the dump, an overdrain diversion channel would be constructed on top of the waste rock dump to convey flows to the south side of the dump for discharge back into the Sheep Rock Creek drainage. A diversion structure would be constructed on the north (upstream) side of the waste rock dump to capture surface and subsurface flows. At the discharge (downstream) end of the overdrain channel, an energy dissipation structure would be constructed to prevent scouring of the creek bed and banks.

There are several reasons for eliminating this alternative from detailed analysis. Construction of a permanent overdrain structure across the East Waste Rock Dump creates additional potential for storm water to contact sulfide waste. Also, high precipitation events and blockage by sediments could cause surface water to breach the overdrain. This water could erode the reclamation cap and expose the sulfide waste. In summary, this alternative would result in the following disadvantages:

- Seepage from the diversion structure could contact sulfide waste rock and produce ARD; and
- Overflow from the diversion could erode reclamation capping and contact sulfide waste rock.

As a result, the agencies eliminated this alternative from further consideration. Other alternatives produced the same results without the disadvantages listed above.

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II.C.2 Cyanide Neutralization Alternative

This alternative was formulated to address potential toxicity to wildlife during mine operations and the need to treat cyanide as part of reclamation. This alternative would require that cyanide levels in the tailings impoundments be kept to 25 to 50 ppm or less to minimize wildlife mortalities. Through evaluation of different cyanide destruction methods, GSM found that the INCO/SO_2 process, while incurring high capital costs, is the most economical method of treating the tailings. GSM is installing an INCO/SO_2 air circuit in 1997. This will lower cyanide concentrations to levels at least 30 ppm or below, eliminating the need to consider this alternative in detail (see Section II.B.1.a, Current Mining Operations).

In addition, GSM has already established a 24-hour, 7-day per week wildlife hazing program to prevent wildlife from entering the tailings area. Equipment used for hazing include three hovercraft to haze waterfowl and shorebirds from beaches and shallow water, two motorboats to haze birds from open water, a rubber raft to haze birds from shallow water, eight 12-gauge shotguns to shoot cracker shells, and eight pyrotechnic pistols to shoot screamer shells. In addition, 12 propane cannons, 2 mobile light plants, a Phoenix Waller MK III sound emission system, 5 blue strobe lights, and a sound system broadcasting high decibel rock music are used to keep wildlife away from the tailings area.

GSM currently uses a wildlife revival technique patterned after first aid procedures developed for humans in cases of cyanide poisoning. When wildlife are incapacitated from contact with cyanide, mine personnel retrieve the animal, wash it with clean water, and administer oxygen and/or amyl nitrate. The animal is observed until it appears to have had a full recovery before release.

Wildlife observations and activities are entered into Daily Hazing Reports. These include the time of observation or activity, the species, number sighted, number hazed, and number of fatalities. These daily reports are summarized by month and are submitted to MDEQ and BLM on an annual basis.

GSM spends approximately $300,000 annually on this program. Since 1991, annual bird mortalities from exposure to tailings cyanide have been kept below 1 percent of the total number of birds hazed. Fencing of the impoundments and reclaim ponds was completed in 1994 and has eliminated access of large mammals to the ponds. No mammal mortalities have occurred since the fencing was installed.

Impoundment No. 2 was designed to limit ponded water by a series of drains through the embankment. Impoundment No. 1 was unlined and had no special drains to limit surface ponding. As a result, Impoundment No. 1 had up to 64.3 acres of ponded water that had to be patrolled until the pond was decommissioned and cyanide was reduced to 30 ppm. Impoundment No. 2 has been in operation since 1993. The amount of ponded water was to be limited to approximately 41.3 acres limiting the amount of wildlife hazing needed for all but shorebirds. The amount of ponded water has been larger than planned because of clogging of the drains. Several attempts have been made to increase drain function. GSM continues to assess drain improvement options. Meanwhile wildlife hazing efforts have been increased to prevent bird losses in the pond until the INCO/SO_2 air circuit is installed.

II.C.3 Acid Neutralization Alternative

This alternative was formulated to address the need for long-term treatment of acid rock drainage from Tailings Impoundment No. 2 after mine closure. This alternative would require that sufficient lime be added to the tailings slurry to prevent the formation of ARD. The most economical method would be to add 118 tons of kiln dust (110 percent $CaCO_3$ equivalent) per 1,000 tons to the tailings slurry. This would involve an initial capital cost of approximately $350,000 for a lime silo, conveyor belt, and mix tank. The operating cost is estimated at an additional $20,709,065 per year, or $144,963,455 through the life of the mine (to 2004).

This alternative was eliminated from detailed analysis primarily because there is no indication that ARD would be a problem at Impoundment No. 2. Once the impoundment has drained down, any infiltration of water through the reclamation cover would be collected in the lined seepage collection ponds. Instrumentation of test reclamation plots and modelling of GSM's proposed reclamation cap both indicate that minimal infiltration would permeate the proposed reclamation cap. GSM estimates this would be less than 10 gpm for the entire Tailings Impoundment No. 2 area. These studies are included in Appendices 5.5-2, 5.6-1, and 5.6-2 of GSM's Permit Application. In addition, Tailings Impoundment No. 2 is fully lined with HDPE. If ARD is formed, it would be collected and treated. GSM has committed to treat any unanticipated tailings seepage in its existing operating permit (GSM 1995a).

This alternative would result in the following disadvantages:

- Additional water consumption would occur as use of recycled water would be eliminated because of scaling problems;
- A long-term treatment system for ARD would still be required for the pit and possibly for long-term seepage from Tailings Impoundment No. 1; and
- Costs would be prohibitive to GSM. Annual operating costs include $20,652,065 for kiln dust ($12 per ton for kiln dust and $58 per ton for delivery), $50,000 for the salary of one full-time operator of the plant, and $7,000 in equipment replacement costs, for a total of $20,079,065 per year. Using the variables provided in Appendix D for estimated mine operating costs and potential profit per ton of ore, and the 1995 GSM figure of 2.5 million tons of ore mined annually, the operating costs of the Acid Neutralization Alternative would far exceed the potential profits of the mine. It would not be economically feasible for GSM to implement this alternative and maintain a profitable operation.

II.C.4 Complete Backfill Alternative

This alternative was formulated to address the same concerns described for the Partial Backfill Alternative. This alternative would involve complete backfilling of the pit with approximately 249 million tons of waste rock to restore premine contours. The estimated cost to GSM of completely backfilling the pit is $81,378,000.

This alternative was eliminated because costs to GSM would be prohibitive. In addition, pit water treatment would continue to be necessary; deeper ore reserves could be precluded from future mining; additional particulates would be emitted; and additional fossil fuels and electricity would be consumed. Finally, it was determined that the partial backfilling alternative addresses all pit reclamation issues adequately.

An economic analysis was conducted to estimate the costs associated with mine pit backfilling and to estimate potential mine profits in order to determine the economic feasibility of complete backfilling of the pit. The detailed analysis is contained in Appendix D. The cost of completely backfilling the pit was calculated by two different methods and then averaged to achieve an estimated value. The first method involved use of a computer program titled *FPC* (a CAT program that estimates costs given a haulage profile and fleet). The second method involved use of generic data from the *Caterpillar Handbook (Edition 26)*. Estimates of the gross value of ore and operating costs were calculated in order to determine a potential profit margin. A base case scenario was then used to generate a typical profit estimate, and then a profit after backfilling estimate. High and low range values also were generated to illustrate a range of potential values.

Under all scenarios (base case, high and low range), the cost of complete backfilling of the pit rendered the alternative economically unfeasible. Profits were reduced below the zero level in both the base case and low range scenarios. Profits remained slightly above zero in the high range scenario, but did not provide a substantial enough margin to render the alternative feasible due to the consideration of other costs, such as capital costs and permitting costs, that were not included in the variable estimates.

It was determined that backfilling the pit with waste rock is only economically viable if it does not involve double-handling of waste rock in amounts representing a substantial percentage of the total tonnage, or if the hauling distances are substantially reduced. Complete backfilling of the pit under this alternative would require double-handling of a significant portion of the waste rock removed. In addition, the hauling distances cannot be reduced to the degree necessary due to the current mine layout and volumes of material involved. Therefore, this alternative is considered economically unfeasible for GSM.

II.D SUMMARY COMPARISON OF IMPACTS AMONG THE PROPOSED ACTION AND ALTERNATIVES

A detailed evaluation of impacts resulting from the Proposed Action and alternatives is provided in Chapter IV, Environmental Consequences. A summary comparison of the impacts associated with each alternative is provided in Tables II-23 and II-24.

Table II-23

Summary Comparison of Areas Affected Under the Proposed Action and Alternatives (Acres)

	No Action	Proposed Action	Return Diversion Alternative	Divided Dump Alternative[1]		3:1 Slope Alternative	No Pit Pond Alternative	Partial Backfill Alternative
				Minimum Scenario	Maximum Scenario			
Permit Boundary Area	5,071	6,125	6,125	6,125 + additional[2]		6,125	6,125	6,125
New Disturbance	0	627	630	407	600	741	627	627
Total Disturbance	2,336	2,964	2,967	2,743	2,936	3,078	2,964	2,964
Total Sulfide-Covered Acres	1,325	1,774	1,774	1,692	1,867	1,899	1,767	1,693
Surface Ownership of Disturbance Area: GSM/Private Land BLM Land State Land	 1,723 613 0	 2,240 689 35	 2,243 689 35	 1,991 752 0	 2,274 662 0	 2,262 780 35	 2,240 689 35	 2,240 689 35
Disturbance Over State Subsurface Lands	357	718	721	448	726	741	718	718
Acres Revegetated[3]	2,128	2,705	2,708	Varies w/areas selected		2,819	2,705	2,940
Acres Not Revegetated	208	259	259	264		259	259	24
Total Waters of the U.S. Disturbance	3.1	4.9	4.9	3.8	4.0	5.4	4.9	4.9

[1] Alternative waste rock dump areas are included in this alternative. Refer to Section II.B.4.a for a description. The agency may select a combination of one or more of the dump areas, in whole or in part, for waste rock disposal. The minimum and maximum scenarios were developed to provide a range of disturbance acreages for purposes of analysis. The minimum scenario utilizes Area C2 for waste rock disposal. The maximum scenario utilizes Areas A, B2, and the land bridge for waste rock disposal. Refer to Tables II-15, II-16, and II-17 for descriptions of disturbance areas, surface ownership, and state subsurface lands associated with each alternative waste rock area.

[2] Under the Divided Dump Alternative, the permit boundary would need to be expanded beyond the area under the Proposed Action if Areas B1, B2, C1, or C2 are selected for waste rock disposal.

[3] Includes areas left undisturbed or that have already been seeded and reclaimed (see Section IV.D, Vegetation and Wetlands).

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II.E AGENCY-PREFERRED ALTERNATIVE

The rules and regulations implementing MEPA and NEPA (A.R.M. 17.4.617 and 40 CFR 1502.14, respectively) require that the agencies indicate a preferred alternative, if one has been identified. Stating a preference at this time is not a final decision. The preferred alternative could change in response to public comment on the Draft EIS, new information that becomes available, or new analysis that might be needed in preparing the Final EIS. The preferred alternative at this time is the Proposed Action as modified by the Return Diversion and No Pit Pond alternatives.

Rationale for Selection

- The Proposed Action best achieves Golden Sunlight's goals for developing its gold reserves. Waste rock dumps reclaimed at the proposed combination of 3:1 and 2:1 slopes are expected to be stable. The oxide rock and soil cap on the dumps provides an adequate medium for revegetation and should minimize soil erosion and water infiltration.

- The Return Diversion alternative, as it modifies the Proposed Action, avoids potential erosion and channel damage problems associated with the proposed diversion of upper Sheep Rock Creek into the tributary of Conrow Creek. The Return Diversion alternative avoids placement of acid-generating waste rock in adjacent drainages, as could occur under the Divided Dump alternative, thus concentrating in a smaller area the anticipated impacts to groundwater associated with ARD seepage from the dumps.

- The No Pit Pond alternative further modifies the Proposed Action to better handle the problem of objectionable effluents from the mine by eliminating the lake of poor quality water that would have formed in the pit after mine closure. This in turn eliminates a potential significant impact to wildlife that might have otherwise come in contact with the pit water.

Select Mitigation Measures

If this alternative is implemented, the following mitigation measures would likely be applied.

- ARD seepage from the existing waste rock dumps as well as from proposed dump expansions is expected in the future. The minimum practicable groundwater mixing zone would be determined and granted. In order to achieve the minimum size for the mixing zone, additional geotechnical and geohydrological characterization of the hydrostratigraphic units downgradient of the waste rock dumps would be performed for both the west and east waste rock dump complexes. This measure would improve the precision of placement and the effectiveness of monitoring and capture wells within the mixing zone by delineating fracture systems and other preferential flowpaths that could allow ARD to move more easily and with less likelihood of being naturally buffered. The mixing zone boundaries would be further refined in accordance with the new information obtained.

  To reduce the amount of ARD seepage reaching the groundwater, drains would be installed below the edges of existing dumps before final contouring and reclamation. Engineered limestone drains would be placed in Sheep Rock Creek and other ephemeral drainages to collect, channel, and partially treat seepage from expanded waste rock dumps on the east side. Collected water would be treated in the water treatment plant.

- Water quality and quantity at existing springs would be monitored. If springs deteriorated, replacement water would be supplied from the water treatment plant, or new sources would be developed. Decreases in water for such beneficial uses as wildlife and livestock watering, due to groundwater drawdown from capture wells and pit pumping, would be compensated for by providing water from the water treatment plant.

The design for the return diversion would be refined to improve stability and efficiency and reduce maintenance requirements. Refinements could include: sizing to carry extreme runoff; excavating into bedrock to improve stability; building to gradients that more closely approach the gradients of the existing channel to improve the diversion's function as a storm water drain and reduce sediment buildup and down cutting, and; lining or grouting to reduce infiltration and improve stability.

In tentatively selecting the preferred alternative and these mitigation measures, the agencies have focused on their major legal requirements under such laws as the Metal Mine Reclamation Act, the Water Quality Act, and the Clean Water Act and the issues that pertain to these requirements. Other issues and possible mitigation measures remain under consideration and will be addressed, following the public comment period, in the Record of Decision after the Final EIS is published.

Pit Reclamation Feasibility

The Partial Backfill Alternative was analyzed in compliance with the Court Order of September 1, 1994, to evaluate the feasibility of pit reclamation, and pursuant to subsequent amendments to the Metal Mine Reclamation Act [at 82-4-336(7), MCA]. Partial backfilling is technically feasible as a method of pit reclamation.

With regard to economic feasibility, GSM provided MDEQ with engineer's cost estimates to accomplish the partial backfilling and reclamation of the pit as described in Chapter II of this Draft EIS. A staff engineer for MDEQ found the cost estimates to be reasonable.

MDEQ contracted an independent certified public accountant to review proprietary economic information provided by GSM containing income and cash flow projections based on the mine's historical costs, a range of gold prices, and the assumption that mining would continue as proposed and that the pit would subsequently be backfilled. MDEQ determined that a positive return on investment in the mine would be the initial threshold for determining the economic feasibility of backfilling. If partial backfilling would eliminate any reasonable likelihood of realizing a positive return on investment, backfilling would be considered uneconomic.

The certified public accountant found GSM's economic information to be reasonable and found nothing to suggest that the underlying assumptions were not reasonable. The projections indicate that a positive rate of return for continued mining under the Proposed Action would be realized only if the price of gold was sustained at $400 per ounce during the analysis period of 1997 through 2003. The return on investment would be very small for the period.

Fluctuations in gold prices will affect the results of the Proposed Action more than any other single factor. Current market indications suggest that the price of gold will average around $350 per ounce through the period with little to suggest an upturn in the near future.

A sustained gold price of $350 per ounce for the period would result in a net loss under the Proposed Action, though with a positive cash flow. This is typical of a mining operation which requires a large initial investment that is recovered over the life of the mine. With gold at $350 per ounce and the requirement to partially backfill, GSM would not be able to recoup its initial investment at a profit.

Based on the analysis summarized above, it does not appear that there would be any reasonable likelihood of GSM realizing a positive return on investment. Therefore, it has been determined that partial backfilling is not an economically feasible method of pit reclamation. Consequently, the agencies' preferred alternative does not include partial backfilling.

CHAPTER III

Affected Environment

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III AFFECTED ENVIRONMENT

III.A GEOLOGY, MINERALS, AND PALEONTOLOGY

This section provides a brief overview of the geologic setting in the vicinity of the Golden Sunlight Mine and summarizes related information such as mineral and paleontological resources, seismic potential, and landslide occurrences.

III.A.1 Hard Rock Geology and Mineral Resources

Detailed technical descriptions of local and regional geology, mineral resources, and related topics are presented in the following references:

- Geology - Foster and Smith (1995); Foster (1991); Foster and Chadwick (1990); Foster et al. (1993).
- Mineral Resources - Paredes, M. (1994); Spry et al. (1995, 1994); Foster et al. (1993).

The Golden Sunlight Mine is located on the southern flank of Bull Mountain. Map III-1 shows a general map of the surficial geology in the vicinity of the mine. Bull Mountain is composed of ancient sedimentary rock that was deposited in a shallow sea during late Precambrian time (also referred to as Proterozoic), approximately 1.4 billion years ago. The Precambrian rock types in the vicinity of the mine include sandstone, siltstone, and shale. These rock units are known collectively as the Belt Supergroup, and also have been referred to as the LaHood, Greyson, and Newland Formations, and the Bull Mountain Shale.

A period of mountain building or tectonic activity known as the Laramide Orogeny occurred during Cretaceous time (approximately 70 to 85 million years ago). In the vicinity of the mine, regional compression of the earth's crust resulted in folded blocks of rock bounded by high-angle (near vertical dipping) faults. Precambrian rocks were penetrated by igneous intrusions and overlain by volcanic materials during this time period. Cretaceous-age intrusive rocks in the vicinity of the mine include latite porphyry intrusions and numerous smaller lamprophyre dikes (refer to the Glossary for these terms).

After the Laramide compressional tectonism, the landscape was relatively stable. Residual (in-place) weathering of the rock surface was the dominant geologic process. During the later Tertiary period, tectonic activity resumed with a period of relaxation of compression, or extension of the earth's crust. This formed the shallow marine basin east of Bull Mountain, which was later filled with Tertiary and Quaternary age sediments. This sediment-filled valley is now the site of the mine and mill buildings, tailings impoundments, and North and East Waste Rock Dumps. The geology of the sediments that underlie these facilities, particularly as it relates to landslides, is the focus of discussion in the following section. Local volcanic activity also is evident by the presence of Eocene age (44-million-year-old) basalt, which is exposed near Tailings Impoundment No. 1. The long period of weathering is indicated by the presence of a red, highly oxidized paleosol (ancient soil) known as the Red Hill Conglomerate, which mantles the bedrock over much of the northeast part of the mine property.

The Precambrian sedimentary rocks in the vicinity of the mine are highly mineralized, or impregnated with sulfide minerals, mostly pyrite. When these sulfide minerals are exposed by mining activities to water and air, they can produce metal-bearing, acidic iron sulfate solutions. These solutions are the source of the potential environmental impact known as ARD.

Low levels of gold are present in the Precambrian sedimentary rocks (up to approximately 0.01 ounce per ton), but the primary concentration of gold, and the target of current mining activity, is a 700-foot-diameter breccia pipe of late Cretaceous-age. The breccia is a zone of broken, angular rock fragments that are cemented together by silica, sulfides, barite, and carbonate. The breccia pipe cuts through both Precambrian sedimentary and Cretaceous intrusive rock at an angle plunging west-southwest. The breccia pipe is shown on geologic cross sections A-A' (Figure III-1) and B-B' (Figure III-2). The

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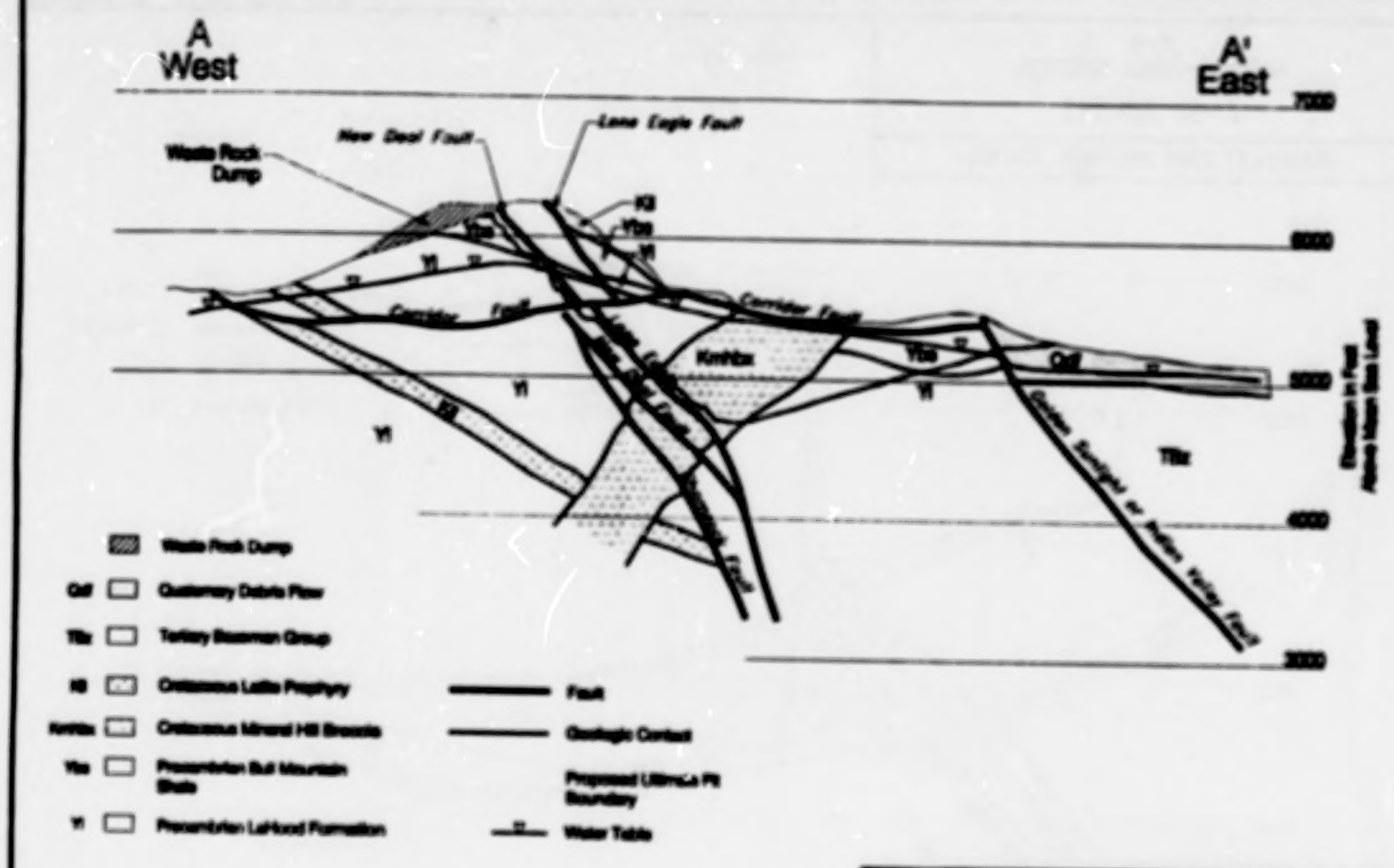
A
West
A'
East
7000
6000
5000
4000
3000
Elevation in Feet Above Mean Sea Level
Waste Rock Dump
New Deal Fault
Lone Eagle Fault
Kl
Ybs
Yl
Corridor Fault
Kmhbx
Qdf
Tbz
Lone Eagle Fault
New Deal Fault
Golden Sunlight or Indian Valley Fault
Waste Rock Dump
Qdf Quaternary Debris Flow
Tbz Tertiary Bozeman Group
Kl Cretaceous Latite Porphyry
Kmhbx Cretaceous Mineral Hill Breccia
Ybs Precambrian Bull Mountain Shale
Yl Precambrian LaHood Formation
Fault
Geologic Contact
Proposed Ultimate Pit Boundary
Water Table

GOLDEN SUNLIGHT MINE EXPANSION

FIGURE III-1

GEOLOGIC CROSS-SECTION
A-A'

SOURCE: DERIVED FROM DSM 1995A (FIGURE 3.12-2)

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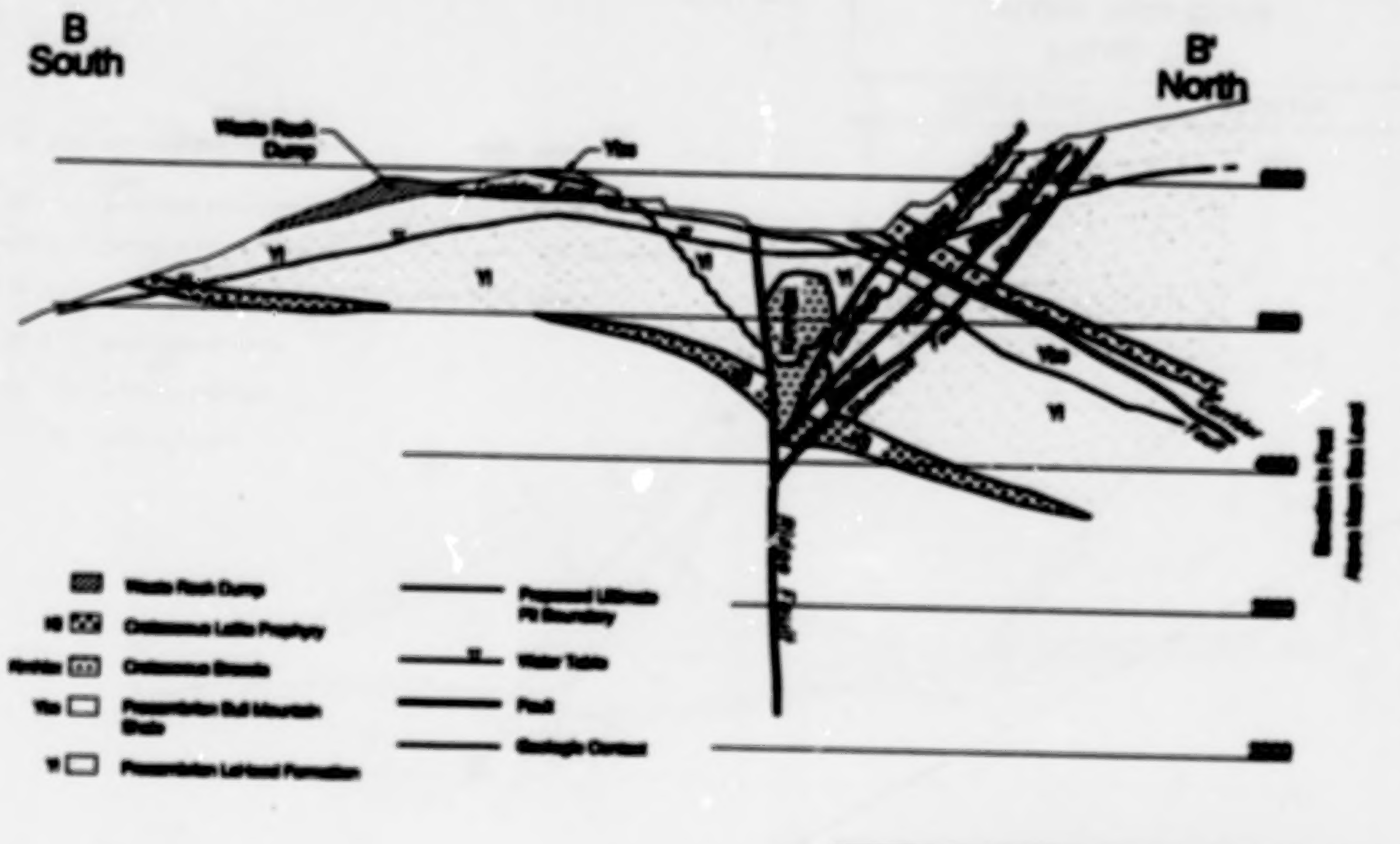
B
South
B'
North
Waste Rock Dump
Ybs
Yl
Waste Rock Dump
Cretaceous Latite Porphyry
Cretaceous Breccia
Ybs Precambrian Bull Mountain Shale
Yl Precambrian LaHood Formation
Proposed Ultimate Pit Boundary
Water Table
Fault
Geologic Contact
Elevation in Feet Above Mean Sea Level

GOLDEN SUNLIGHT MINE EXPANSION

FIGURE III-2

GEOLOGIC CROSS-SECTION
B-B'

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locations of these cross sections are indicated on Map III-1.

Gold occurs primarily as very fine grains (micron-sized particles) of ore that are disseminated within the breccia pipe and immediately adjacent rocks. Free gold (i.e., gold that is uncombined with other substances) occurs interstitially, as microscopic (5- to 100-micron-sized) particles between pyrite grains. Gold-bearing tellurides are present in minor amounts. Total reserves at Golden Sunlight Mine, including those mined since 1983, include approximately 55 million short tons grading 0.059 ounce of gold per ton, with an average waste:ore stripping ratio of 7.4:1. The mine currently has an active exploration program to identify additional reserves. The mineralized breccia zone has been drilled 1,500 vertical feet from the bottom of the existing pit. Exploitation of additional ore at depth within the breccia pipe is largely dependent upon gold prices and operating costs.

Pyrite is by far the most abundant metallic mineral. The average range of pyrite in GSM ore is between 3 percent and 5 percent. Concentrations of up to 20 percent can occur, but are not typical. The relatively fine texture of this pyrite enhances the surface area available for ARD generation. Other metallic minerals occur in minor amounts within waste rock and vary in accordance to position in the ore body. Metals of potential concern for water treatment of effluent include aluminum, cadmium, copper, zinc and arsenic. With exception of aluminum, the other metals are predominately associated with sulfide complexes and minor oxides.

A number of smaller geologic structural features that may contain economically retrievable metals have been identified in the mining district. Most of these occur along a northeast-trending mineralized zone that extends through the mine area. The feasibility of developing these areas will largely be dependent upon extent of mineralization, gold prices, and operating costs. Any further expansion other than that proposed in this EIS analysis would require the preparation of another application for an amendment of the operating permit and another environmental analysis. See Cumulative Impacts (Section IV.D in Chapter IV) for further discussion regarding expansion potential for the mine.

Tertiary Bozeman Group sediments, and older Paleozoic rocks exist to the east and northeast of Bull Mountain and the Mineral Hill Pit. These rocks and sediments have diverse lithologies ranging from to low permeability clays to carbonate-rich shales and limestones. Select rock units are suitable for specialized construction applications and locally exhibit high acid neutralization potential. Some of these acid neutralizing rock materials represent potential mineral resources. Specifically, limestone resources have been identified in the vicinity of the Proposed Action (expanded) East Dump. The Belt Supergroup rocks (i.e., argillites) west of the mine have low acid neutralization potential.

III.A.2 Geology and Geotechnical Considerations

III.A.2.a Engineering Geology and Hydrogeology

The mine plant, tailings impoundments, existing waste rock dumps to the north and east of the plant site, and the Proposed East Waste Rock Dump area are all situated in a horseshoe-shaped valley east of Bull Mountain. The head of the valley is bounded by exposed bedrock. The valley is filled with unconsolidated sediments of Cenozoic (Quaternary and Tertiary) age. The valley-fill sediments are only a few feet thick around the northern margins at the U-shaped valley head, but typically thicken towards the central part of the valley to several hundred feet overlain on bedrock. The physical characteristics of these valley-fill deposits are important because these sediments convey groundwater that may be impacted by cyanide, ARD or by other contaminants associated with mining activities, and because landslides have occurred in these materials in the immediate vicinity of the mine. This subsection provides a brief overview of the Tertiary and Quaternary geology as it relates to hydrogeologic features and landslides. For a more detailed description of the local and regional geology relevant to landslide interpretation, including an extensive bibliography, refer to Golder (1995a).

Map III-2 is a surficial geology map of the valley-fill sediments in the vicinity of the mine. The general stratigraphy (vertical sequence) of these sediments is shown on Figure III-3. Late Tertiary and early Quaternary age surficial deposits cover much of the permit area east of Indian Valley (Golden Sunlight) Fault and consist primarily of thin (on the order of tens of feet thick) colluvium (Qc), alluvium (Qal), and surficial landslide deposits (Qls) and as gravelly fan-terrace deposits (Qft). These deposits do not have a significant saturated thickness below the groundwater table, but may contain discontinuous lenses of fine-grained materials that can become saturated by infiltration, forming shallow "perched" groundwater zones.

Tertiary sediments on the order of hundreds of feet thick generally underlie the thin Quaternary deposits, but are exposed at the surface in places (see Map III-2). Several separate Tertiary units have been defined including landslide deposits (Tls), debris flow deposits (Tdf), gravel (Tg), sand (Ts), Red Hill Conglomerate (Tcgl), and the Bozeman Group (Tb). Tertiary landslide and debris flow deposits, and colluvium consist predominantly of sandy or silty gravel beds, and can be up to 250 feet thick. These deposits form important hydrostratigraphic features (groundwater conveyance zones), due to their relatively high permeability.

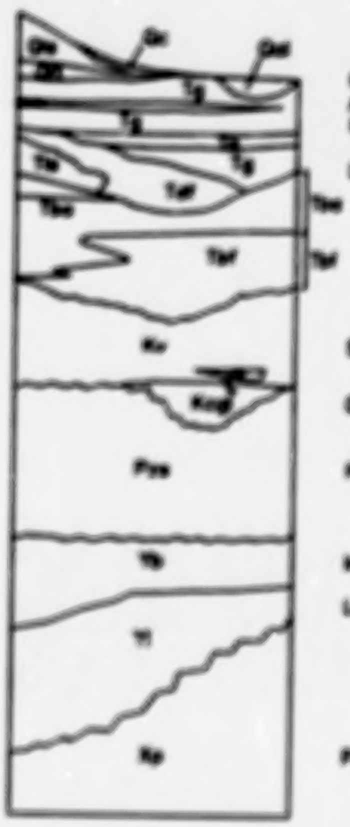
The Bozeman Group is the most extensive valley-fill deposit in the area and is the most important geologic feature in terms of off-site groundwater conveyance and slope stability. The Bozeman Group has been subdivided by geologists into two units. The lower unit (fluvial facies, Tbf) comprises clay-rich overbank muds with incised channel deposits of unconsolidated pebbly sand. The coarser-grained upper unit (alluvial fan facies, Tba) is composed of semiconsolidated gravelly mudstones (Foster et al. 1993; Golder Associates Ltd. 1995a, 1995g). The bulk permeabilities of both facies of the Bozeman unit are relatively low due to their high fines content, although localized lenses of sand and gravel provide zones of moderate to high permeability. Clay layers exist within the lower Bozeman unit (Tbf), and at the contact between the fluvial and alluvial facies. Natural landslides have occurred in the immediate vicinity of the mine and are attributed to slip along the weak Tbf/Tba contact.

The Bozeman Group and other surficial materials on the east side of Bull Mountain have a wide range of potential uses and benefits, notably as sources of construction materials for tailings embankments, liners, and aggregate materials, and as acid-neutralizing materials for use in berms and covers over mineralized areas. The predominantly low-permeability sediments limit regional transmission of groundwater, and important archeological and paleontological resources have been identified [illegible] the immediate vicinity of the [illegible]pacted area.

III.A.2.b Ground Movements

Ground movements in the mine area are categorized according to three distinct mechanisms of instability: 1) sliding of materials off Bull Mountain on steep, near-surface, shear planes; 2) relatively slow movement of massive blocks of valley fill sediments along deep, low-angle shear surfaces (especially at the Tba/Tbf contact); and 3) sliding of fault-bounded blocks of bedrock along shear planes due to loss of lateral support caused by pit excavation. The first type of ground movement is referred to as a landslide in the geotechnical reports, and the second and third types are called earth block slips or landslips (Golder Associates Ltd. 1995a). The first two types of ground movement are the result of long-term natural geologic processes. The third type of movement may be caused by human activities (such as mining).

Map III-3 is a composite of the features that are relevant to ground movements at the Golden Sunlight Mine, including the known landslides and block slips that have moved recently, potential ancient landslide features, constructed and proposed landslide buttresses, and

SYMBOL	THICKNESS	GRAPHIC COLUMN	DESCRIPTION
Qfl,Qls,Qc,Qa	0-60'	 Qls Qa Qc Qfl Ts Tg Tls Tsf Tba Tbf Kv Kcgl Pzs Yb Yl Xp	Quaternary Deposits
Tg/Ts	0-360'		Alluvial Fan gravels with intercalated lacustrine beach sand
Tsf/Tls	0-250'		Landslide and Debris flow deposits
Tba Tbf	0-+1500'		Alluvial Fan Facies Fluvial Facies] Bozeman Group (Tb)
Kv	+5000'		Elkhorn Mtn. Volcanics
Kcgl	0-1500'		Conrow Creek and Red Hill Conglomerate
Pzs	+4000'		Paleozoic sediments (undifferentiated)
Yb	+3000'		Informal Bull Mtn. Group] Belt Supergroup
Yl	+3000'		LaHood Fm.
Xp	not exposed in map area; found only as xenoliths in Cretaceous intrusive igneous rocks		Pony Series Metamorphics

GEOLOGY BY T.H. Chadwick
FIGURE MODIFIED FROM GOLDER ASSOCIATES Ltd.(1995a)

GOLDEN SUNLIGHT MINE EXPANSION

FIGURE III-3

TYPICAL STRATIGRAPHIC COLUMN
VALLEY-FILL SEDIMENTS

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proposed dump and borrow excavation outlines. These features are described below.

Midas Slump

During exploration of the site for its mineral resources, geologists identified a surficial landslide northeast of the current mill facilities area. This natural feature was called the Midas Slump. The Midas Slump affected an area of approximately 86 acres and is outlined on Map III-3. A stability assessment for waste rock dumps being placed over the slump area was reported by Seegmiller (1987, 1988). The Midas Slump became an operational problem for the mine when waste rock was being placed over the slump area. The waste rock dump tended to settle excessively because the unstable foundation soils were continuously displaced out from under the dumped material. To stabilize this area, a waste rock dump was constructed around the down slope (south) end of the Midas Slump in late 1993. The intent was to provide a buttress, called the Midas Capture Dump, to contain the ground movement. This effort was successful and did arrest the Midas Slump ground movement.

Sunlight, Rattlesnake and Swimming Pool Block Movements

In the spring and summer of 1994, additional ground movements were detected. These movements were caused by reactivation of three distinct, but interrelated block slips named the Sunlight Block, the Rattlesnake Block, and the Swimming Pool Block. Map III-3 outlines these block slips. The southern limit of the Midas Slump material was found to be roughly coincident with a segment of the head scarp of the Sunlight Block. Arrows within the block slip outlines on Map III-3 indicate the general direction of measured movements of the blocks between August and November 1994. Movement of these block slips impacted many of the mine facilities.

Earth block slip movements in the valley fill sediments are geologically historic and are believed to have begun during a period of active tectonism in the late Tertiary or early Quaternary, about 2 to 3 million years ago (Ruppel 1993). Characteristic movement occurs as blocks of earth slowly slide downhill along previously sheared, planar slip surfaces that are gently tilted from horizontal. The sliding surfaces generally follow the Tertiary bedding planes, which slope at 3° to 6° from horizontal. The slip planes are very deep, typically about 150 to 300 feet below the ground surface. The subsurface failure planes are very thin and occur in weak, clayey materials within the lower Bozeman Group unit (Tbf). The ancient block slips were evidently stable in recent times. Movement was probably stabilized because of changing (lowering) groundwater levels compared with conditions at the time the slide was initially activated. The block slips were reactivated by mining activities in April 1994. Reactivation of the ancient block slips was made possible because the subsurface slip planes were already well-developed by past sliding and were pre-sheared to very low (residual) shearing strength. The cause of the movement was identified, and the block slips were stabilized through mitigative earthwork by October 1994. A brief description of the chronology of events, the diagnosis of the block slip mechanisms, and the mitigation undertaken to stabilize the block slips are provided in the following paragraphs.

The Sunlight Block is the easternmost and largest of the three block slips and covers roughly 520 acres. The Rattlesnake Block is a smaller piece (roughly 200 acres), which is separated from the Sunlight Block by the Rattlesnake Fault. Both the Sunlight and Rattlesnake Blocks are situated within the valley-fill sediments. Rattlesnake Fault is a northwest-trending fault that separates the two distinct blocks. The stratigraphy within the Tertiary and Quaternary deposits is different on either side of the Rattlesnake Fault in the vicinity of the block slip mass. The Sunlight Block on the east contains both the fluvial and the alluvial facies of the Bozeman Group, whereas in the Rattlesnake Block, the fluvial facies is overlain by more permeable Tertiary landslide deposits, colluvium, and debris flow deposits. Large differences in groundwater elevations have been observed in borings on either side of the fault (Golder Associates Ltd. 1995a, 1995g).

The Swimming Pool Block is a much smaller (25-acre) slab of earth that is situated within the Precambrian/Cretaceous bedrock and is bounded on all sides by faults. The northeast side of the Swimming Pool Block is daylighted in the Mineral Hill Pit, where the bounding Corridor Fault is exposed. This block slip is of the third type of instability, which was described in the first paragraph of this section.

Ground movement was initially detected in April 1994, in the vicinity of the Swimming Pool Block. About that time, cracks were noticed in the concrete walls and floors within the plant area. Mill operations were voluntarily suspended by GSM on June 14, 1994. The full extent of the block movement was not understood until after August of that year. The area that was ultimately impacted by the slide is approximately 7,000 feet north-south by 3,800 feet east-west, and includes the mill/plant site, portions of the waste rock dumps, and the northern part of Tailings Impoundment No. 1.

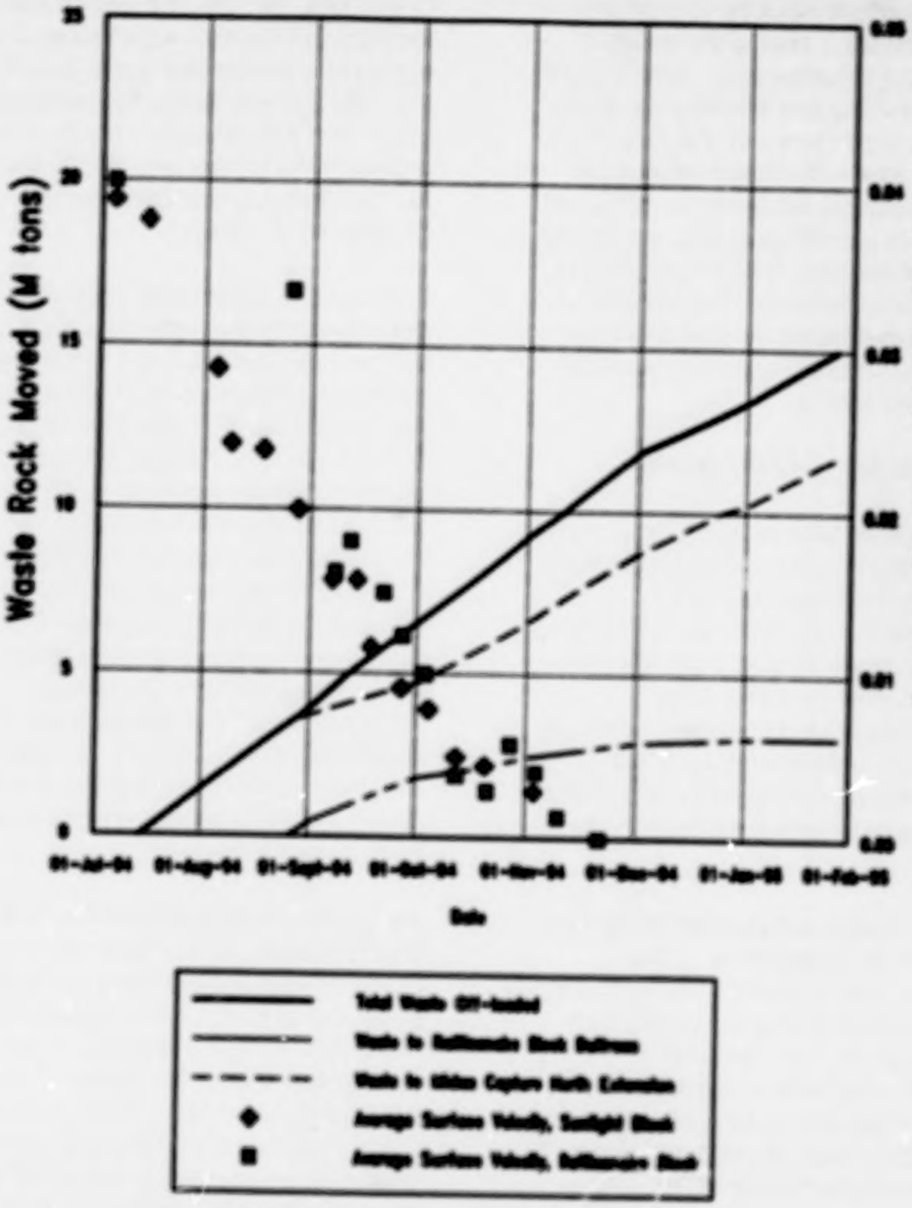
Geotechnical studies conducted by the mine in 1994-1995 concluded that movement was triggered by placement of mine waste rock dumps at the head of the Sunlight Block (Golder Associates Ltd. 1995a, 1995b, 1995g). A cross-section through this block parallel to the direction of movement is shown on Figure III-4. The location of this cross-section is indicated as section MPS-MPS' (for Movement Parallel Sunlight Block) on Map III-3. According to the geotechnical interpretation, once movement of the Sunlight Block was initiated, drag along the Rattlesnake Fault induced movement of the Rattlesnake Block. These movements, in turn, reduced lateral restraint along the east side of the Swimming Pool Block where it is bounded by the Indian Valley Fault. (The Indian Valley Fault also is known locally, in the vicinity of the mine, as the Golden Sunlight Fault.) Some of the generally eastward movement of the Swimming Pool Block also is attributed to reduced lateral stresses that occurred when the northwest segment of the block was exposed by the pit excavation.

Movements within the Rattlesnake Block were accelerated and increased with proximity to the North Borrow Area, which now underlies the area labeled Rattlesnake Block Buttress on Map III-3. This accelerated movement indicated that the failure mode in this part of the Rattlesnake Block was retrogressive, or propagating up the slope from a localized overstressed zone in the borrow pit area. Total mass movement was on the order of 3.5 feet for the Rattlesnake Block during the 1994 event.

Block slip movements were halted and stabilized by a combination of removal of waste rock from the head of the Sunlight Block and placement of a stabilizing buttress at the toe of the Rattlesnake Block. The pre-unloading and post-unloading limits of the waste rock dump are indicated on the MPS cross-section, Figure III-4. The limits of the Rattlesnake Block Buttress are indicated of Map III-3. The Rattlesnake Block Buttress was intended to fill in the North Borrow Area pit and halt the retrogressive failure at that location. A total of 15 million tons of waste rock were removed from the head of the slide area. Approximately 3.5 million tons of the off-loaded waste rock were placed as the Rattlesnake Block Buttress. The remaining 11.5 million tons were placed on stable ground northeast of the area of movement.

Figure III-5 shows how the average rate of movement of the Sunlight/Rattlesnake block slip complex declined consistently during unloading of the Sunlight Block and placement of the Rattlesnake Block Buttress. Movement apparently stopped once about 8 million tons were off-loaded from the head of the slide. No additional movements were detected until the fall of 1995, when two inclinometers indicated about 0.5-inch of movement had occurred on the Rattlesnake Block in the vicinity of the Rattlesnake Block Buttress. These movements occurred sometime between September and November in inclinometers located north and south of the buttress fill. Block slip movement was attributed to resloping activities on the south face of the Rattlesnake Block Buttress. These reclamation activities were being done at about the same time the movement was detected.

The geotechnical analyses estimate that the waste rock dump unloading has increased the



NOTE: MOVEMENT RATES ARE RUNNING AVERAGES OVER SEVERAL WEEKS, THEREFORE CONTINUE TO INDICATE MOVEMENT AFTER BLOCK MOVEMENT STOPPED.

GOLDEN SUNLIGHT MINE EXPANSION

FIGURE III-5

WASTE ROCK UNLOADING AND BLOCK MOVEMENT RATES

SOURCE: DERIVED FROM GOLDER ASSOCIATES LTD. 1995 (FIGURE 7)

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stability of the Sunlight Block by 11 percent relative to the condition prior to the onset of noticeable ground movement (i.e., prior to April 1994). Prior to mining and modification of the topography, the safety factor for the failure area was estimated to be 1.22 (Golder Associates Ltd. 1995g). Additional buttressing is scheduled during the interim permitting period, and as part of the Proposed Action to further improve the stability of the Sunlight Block. The impacts of these proposed buttresses are discussed in Section IV.A.1.a, Geologic Impacts Associated with Discontinued Mining.

III.A.2.c Faulting and Seismicity

The Golden Sunlight Mine is located in a region known as the Intermountain Seismic Belt (ISB) (Smith and Sbar 1974; Stickney and Bartholomew 1987). The ISB is sharply defined in this area by historic seismicity along about a 50-mile-wide, northerly trending zone. Ninety-five percent of the earthquake activity in the region occurs within this zone. Most of the historically measured earthquakes in the vicinity of the site are very small and are referred to as micro-earthquakes.

The closest significant earthquakes (magnitude >5.0) appear to be concentrated in the Clarkston Valley, about 30 miles east of the site. The largest recorded earthquake in this area occurred on June 28, 1925, and had a magnitude 6.75. The seismic activity in the Clarkston Valley appears to be related to northwest-trending faults of the Willow Creek fault zone (Qamar and Hawley 1979).

Several large (magnitude 6.0 or greater) earthquakes have been historically recorded within about 100 miles of the site. The Yellowstone Park area, located about 90 miles southeast of the mine site, experiences the most intense earthquake activity in the ISB. This activity is attributed to movement along the Madison Fault system, which extends north from the Yellowstone area to within about 32 miles from the site (Smith 1978; Trimble and Smith 1975; Smith and Sbar 1974).

About 25 miles north of the site is another historically active area known as the Lewis and Clark Zone. In 1935, the Helena area, which is included in this zone, experienced a swarm of earthquake shocks that lasted over 6 months and included two destructive earthquakes of 6.25 and 6.0 magnitudes. None of the seismic activity in the Helena area produced surface faulting (Stickney and Bartholomew 1987; Freidline et al. 1976).

According to site-specific seismicity studies done in connection with the design of the tailings impoundments, the maximum credible earthquake (MCE) could produce a peak horizontal ground acceleration at the site of 0.2g (20 percent of the acceleration due to gravity) (Sergent, Hauskins & Beckwith 1981, 1988). The basis for this design earthquake event was a 7.5 magnitude earthquake occurring along the Madison Fault System where it lies closest to the site. This potential peak ground acceleration was used to assess the seismic stability of the tailings impoundments. The tailings dams were determined to be stable with a sufficiently large margin of safety to rule out the possibility of permanent deformations under the design earthquake (AGRA 1995).

An intense, highly localized site investigation was conducted on the "East Bench" area east of Tailings Impoundment No. 2 to investigate the possibility of recent minor fault activity in the immediate vicinity of the impoundment (SHB-AGRA 1993). No evidence was found of recent (within the last 10,000 years) fault activity in the area, and the potential for surface rupture faulting in the immediate vicinity of Tailings Impoundment No. 2 was determined to be very low.

Seismic analyses also were done to assess earthquake stability for the Midas Capture Dump Northeast Extension (Golder Associates Ltd. 1995d), for the reclaimed Sunlight Dump (Golder Associates Ltd. 1995e), for the West Waste Rock Dump Stage 5 (Golder Associates Ltd. 1995f), and for the East Buttress Extension (Golder Associates Ltd. 1995h). These analyses indicated that although catastrophic failure of the waste rock dumps and buttresses would be unlikely under the design earthquake event, localized deformations varying from less than 1

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to up to 7 to 8 feet should be anticipated. The likelihood of occurrence, and the potential environmental consequences of these deformations are described in Section IV.A.

III.A.2.d Geology of the East Waste Rock Dump Expansion Area

Surface mapping and a detailed geotechnical site investigation of the proposed east dump expansion area were carried out during 1994 and 1995, as documented by Golder (1995i). The proposed East Waste Rock Dump is outlined on Map III-3. The proposed dump will extend the East Interim Dump northeastward across the Sheep Creek drainage. The upper foundation for the proposed dump expansion is comprised mostly of thin surficial Quaternary alluvial fan-terrace deposits (Qft) and exposed Tertiary Bozeman Group sediments (Tba), although a portion of the northernmost part of the ultimate dump would rest directly on bedrock.

Bedrock is present below the proposed dump area at depths ranging from 0 to over 500 feet and is exposed at the ground surface at elevations above 5,050 feet. Bedrock in this area is composed predominantly of ancient sedimentary rocks (sandstones, limestones, and shales) of Precambrian to Devonian age. The upper bedrock surface is highly weathered and altered into clay layers in some places. The sedimentary bedrock has been fractured, faulted, and folded, resulting in local variations in bedding orientation. The prevailing strikes are north-northeasterly, and dips are steep (about 60°) to the northeast.

The proposed East Waste Rock Dump site is situated near the northern margin of the valley-fill deposits, with the bedrock surface generally deepening and widening beneath the proposed dump towards the south. A typical geologic cross-section of the materials that form the foundation for the East Waste Rock Dump is shown on Figure III-6. The location of this cross-section, labeled ED-ED' (for East Waste Rock Dump), is shown on Map III-2.

Immediately overlying the bedrock surface over much of the East Waste Rock Dump area is a thin layer (0 to 40 feet) of Tertiary gravels, sands, and clays (Tcgl) (also known as the Red Hill conglomerate). This unit is highly variable in thickness and composition. Extensive slickensides are common where the unit is clayey, but most of the unit is composed of gravel and sand.

Bozeman Group sediments that underlie the footprint of the proposed East Waste Rock Dump consist of a thin to moderately thick (10 to 100 feet thick) bed of the silty alluvial-fan facies (Tba), underlain by interbedded Tba and the more clayey fluvial facies (Tbf). Substantial layers of gravel and gravel/clay interbeds also are present within the Tbf/Tba unit. These gravelly layers are interpreted as Tertiary debris flow deposits (Tdf), as indicated on Figure III-6. Alluvial fan sediments occur up to a maximum elevation of approximately 5,200 feet. Fluvial sediments are predominate below 4,900 feet in this area. Numerous slickensides and fissured zones were encountered throughout the fluvial deposits during the site investigation. However, only those of certain orientation are a stability concern.

The Bozeman alluvial sediments (Tba) are exposed at the ground surface under the proposed dump site where the Sheep Creek channel is incised, but most of the ground surface that will directly underlie the dump is covered by a thin veneer of Quaternary fan-terrace deposits (Qft). These soils are generally gravelly with highly variable amounts of sand, silt, and some clay. (Note that this thin veneer of gravelly soil is not indicated on the cross sections, Figures III-4 and III-6.)

A possible Tertiary-age block slip was identified from a semi-circular feature on aerial photographs in the East Waste Rock Dump area. This feature is outlined on Map III-3. The geotechnical site investigation conducted by Golder in 1994-1995 (Golder Associates Ltd. 1995i) did not reveal any evidence of recent large scale movement of this ancient slump or

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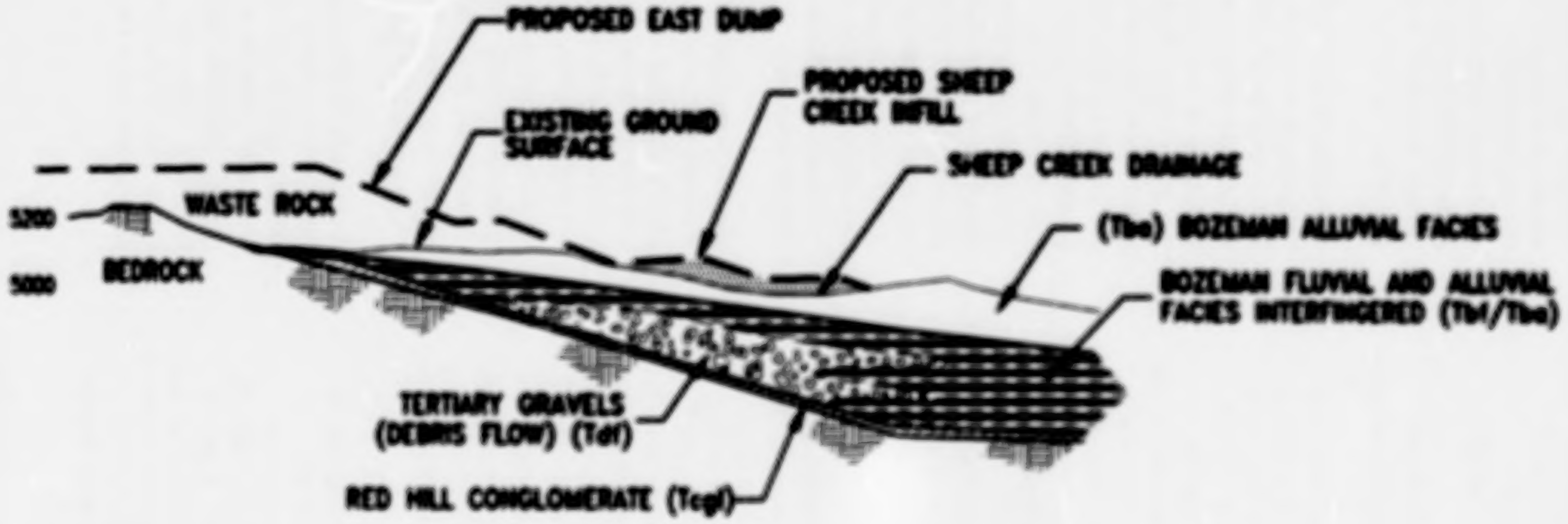
PROPOSED EAST DUMP
PROPOSED SHEEP CREEK INFILL
EXISTING GROUND SURFACE
SHEEP CREEK DRAINAGE
5200
WASTE ROCK
5000
BEDROCK
(Tba) BOZEMAN ALLUVIAL FACIES
BOZEMAN FLUVIAL AND ALLUVIAL FACIES INTERFINGERED (Tbf/Tba)
TERTIARY GRAVELS (DEBRIS FLOW) (Tdf)
RED HILL CONGLOMERATE (Tcgl)

GOLDEN SUNLIGHT MINE EXPANSION

FIGURE III-6

EAST DUMP GEOLOGIC
CROSS-SECTION ED-ED'

SOURCE: MODIFIED FROM GOLDER ASSOCIATES LTD. [illegible] (FIGURE 7)

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of the presence of a consistent shearing plane below the ground surface. Although plastic clay interbeds (Tbf) were found to be locally developed beneath the outlined area, the prevalent dip direction of these interbeds is towards the south-southwest, whereas the potential block slip movement is towards the west-southwest. Thus, there was no conclusive evidence to connect the apparent surface manifestation of an ancient slump to a potential subsurface slip plane, and it was concluded that the aerial photo feature was not due to slumping.

The most significant structural geologic feature in the East Waste Rock Dump area is the Sheep Rock Fault. The precise location and magnitude of displacement of this regional, northwest-trending fault is unclear in the area south of Bull Mountain, because its surface expression is obscured by valley-fill sediments. In the area of the proposed East Waste Rock Dump, the fault separates Tertiary and Paleozoic formations. A set of right-normal faults perpendicular to the Sheep Rock Fault has been identified in the vicinity of the East Waste Rock Dump expansion area (see Map III-2). These right-normal faults offset both bedrock and Tertiary Bozeman Group sediments, but not the surficial Quaternary deposits. One of these right-normal faults is coincident with the southeast boundary of the potential ancient block slip shown on Map III-2.

Four piezometers were installed as part of the geotechnical site investigation of the East Waste Rock Dump area. These piezometers indicate that the groundwater levels are within the bedrock and range from 4,600 to 4,800 feet in elevation in the vicinity of the proposed dump extension. The measured groundwater levels are well below potential landslide or block slip failure surfaces within the valley fill sediments. There is the potential for localized perched water tables to exist within the Tertiary sediments.

Two important differences can be noted between the geologic conditions in the vicinity of the proposed East Waste Rock Dump area and the conditions in the vicinity of the Sunlight Block.

1. Bedding Plane Orientation: The Sunlight Block slid along a well-defined slip surface. This surface was the gently tilted bedding plane that separates the stronger upper alluvial materials from the weaker underlying fluvial unit of the Bozeman Group (i.e., the Tba/Tbf boundary). This slip surface is tilted towards the southeast at roughly 5° to 6°, and is shown in cross-section parallel to the direction of movement on Figure III-4. The prevalent orientation of bedding planes within the Bozeman unit in the vicinity of the East Waste Rock Dump is towards the southwest, at roughly 5°. This is shown as the Tba/Tba-Tbf boundary on Figure III-6, which is a cross-section taken approximately parallel with the bedding plane dip direction.

2. Stratigraphy: The Sunlight Block is comprises a roughly 150- to 440-foot-thick mass of strong, partially calcite-cemented materials (Tba), which slid as a coherent block along the failure plane. The large mass of this block is the main driving force for the movement. The proposed East Waste Rock Dump is sited close to the margin of the valley, where the overlying Tba unit is much thinner in comparison (between 10- to 100-feet-thick in the vicinity of the proposed East Waste Rock Dump).

   Also, near the northern margin of the valley, the lower Bozeman Group unit tends to be interfingered with granular materials. Instead of a homogeneous mass of clayey material containing a few incised channels of granular soils, the unit is characterized in this area by alternating layers of the clayey fluvial (Tbf) and the gravelly alluvial (Tba) or debris flow (Tdf) materials.

These characteristics of the geology in the vicinity of the Proposed Action expansion of the East Dump indicate that there is moderate likelihood of initiating another block slip due to placement of the Proposed Action East Dump. This is discussed in relation to environmental consequences of the Proposed Action and considered Alternatives in Section IV.A.

III.A.2.e Tailings Impoundments

Refer to Map I-2 for locations of Tailings Impoundments No. 1 and No. 2. Tailings Impoundment No. 1 was decommissioned in 1990 but continued receiving slurry until the end of 1995 to produce a reclamation surface. Mill tailings that currently are produced by ore processing are conveyed in a fluid slurry from the mill building to Tailings Impoundment No. 2 via a 12-inch diameter HDPE pipeline. The pipeline is being replaced by a double-lined pipe to be redesigned and completed during 1996 and 1997. The tailings slurry is approximately 50 percent solids. Tailings Impoundment No. 2 is currently designed to accommodate 35 million tons of tailings material, with sufficient additional capacity to handle a 6-hour PMP event with 5 feet of freeboard.

The tailings dams are designed to be stable with acceptable factors of safety against slope failure under static and earthquake loading conditions. The stability of the tailings impoundments relative to the potential for earth block movements in the foundation was assessed by a study done in 1995 (AGRA 1995). That investigation concluded that: a) there is no evidence of extensive pre-sheared, residual-strength potential slide surfaces in the clay units beneath the tailings impoundments and b) stability analysis based on conservative assumptions indicates a high margin of safety against earth block movements in the foundations of the tailings impoundments.

III.A.2.f Mine Pit Walls

The main portion of the mine pit is roughly circular in plan. The pit is open to the east, with the "lip" of the pit at approximately elevation 5,350. The main floor of the pit is at elevation 5,075, and a wide bench is present at elevation 5,700 at the end of the *Interim Dump Plan*. The pit under the *Interim Dump Plan* has a crest elevation of approximately 6,300 at the northwest side of the pit, and the total surface area of the main pit is approximately 312 acres. The surface area below the "lip" of the pit is approximately 30 acres.

The pit walls are characterized by slopes and benches. The angle of the faces between the benches (bench face angle) is about 61°, which is used throughout the pit. A slope height between benches of 50 feet is typically used, with some slopes of 100 feet in height. The width of the benches varies, depending on the desired overall pit wall slope angle. A minimum bench width of 22 feet is used for 50-foot tall slopes.

Along the general trend of the northwest pit wall, there is a series of faults that dip to the southeast and northwest at 70° to 90° to horizontal. These faults have the potential to generate slope failures within the pit, due to rock material sliding on the fault planes. Currently, there is rock mass slope instability in this sector of the pit wall, although ongoing mining is following the pit configuration plan, which is designed to mitigate this stability problem as part of the *Interim Dump Plan*. Slopes along the northwest wall of the pit are being flattened as part of this newer design, from that in the original pit design, in order to mitigate stability problems due to the unfavorable orientation of these faults.

III.A.2.g Plant Site Building Foundations

The mill site buildings and related structures are constructed on an extensive and thick sequence of alluvial fan sediments that exist southeast of the pit. In situ density testing of the near surface soils and fills and downhole geophysical density logging were performed in 1994 to investigate the impacts of block slip movements on the mill site foundations (Golder Associates Ltd. 1995b). Tests revealed potentially metastable soil conditions that are not directly related to block slip movements, but which could be indirectly impacted by those movements. These metastable conditions refer to the presence of loose, granular soil layers within the alluvial fan deposits that underlie the mill site area. If these loose layers become wetted, rapid settlement or collapse of those zones of soil is likely, especially if they underlie heavily loaded foundations.

No significant settlements or evidence of foundation distress were observed until the spring of 1994. Structural damage attributed to foundation settlement was observed in conjunction with block slip movements in April of that year. The geophysical mapping indicated that significant wetting had occurred near and beneath the southeast portion of the leach tanks. Total settlements up to 9 inches were estimated beneath Leach Tank Six, and smaller settlements were observed in the three adjacent tanks in the same area. These settlements caused cracking of the floor slab around the tanks and opening of gaps in the structure. It was considered likely that wetting had occurred due to leakage from a buried fire line, which had been damaged by the east-west extensional ground movements across the mill site at the time of the block slips. Significant lateral movements and some settlement also were observed in the mill site grinding circuit and chemical storage areas.

Remedial measures were implemented to improve the foundation conditions and enhance stability, including:

- Compacting grouting under the pyrite leach tanks and beneath the main grinding circuit foundation;
- Regrading the mill site to prevent ponding of water;
- Installing a fiber reinforced PVC liner to provide a surface seal around the leach tanks; and
- Sealing of open cracks and joints.

Permanent baselines and reference locations were established on the mill site, and an on-going program is in place to monitor ground movements in the area.

III.A.3 Paleontological Resources

Paleontological resources or fossils are the physical remains, impressions, or traces of plants or animals from past geologic ages. Paleontological resources are important mainly for their potential to provide scientific dating information, information on the evolutionary history of plants and animals, and information on paleoenvironments and paleoclimates. Vertebrate fossils are generally considered to be the most significant; however, rare occurrences of invertebrates, plants, and other diagnostic fossils also can provide valuable information.

The majority of the Golden Sunlight Mine is located on Bull Mountain, which is composed of Precambrian through Tertiary-age rocks. Fossils have not been found in Precambrian deposits located in the area. Paleozoic strata in the area can include occasional invertebrate fossils; however, these fossils are not generally considered significant. No fossiliferous formations have been found in Mesozoic strata in the project area (Lindsey 1994). The east and west portions of Bull Mountain contain Middle Tertiary and Quaternary basin fill deposits. The Tertiary fill deposits found on Bull Mountain are known as the Bozeman Group and contain two lithostratigraphic units, a lower Oligocene-age Chadronian unit, and an upper unit of unknown age (Lindsey 1994). Vertebrate fossil localities have been identified in Tertiary-age rock found on the mine site (Hanneman 1996).

Tertiary-age vertebrate fossil localities also have been identified to the south, east, and west of Whitehall, Montana, within the Lower Oligocene-age Chadronian unit of the Bozeman Group and in the Miocene-age Six Mile Creek Formation. The Chadronian unit ranges in age from 30 to 35 million years before present (B.P.) and includes fossil insectivores, rodents, brontotheres, oreodonts , small rhinoceros, horses, primitive camels, and carnivores. The Six Mile Creek Formation contains horse, rhinoceros, oreodont, carnivore, and camel fossils (Lindsey 1994)

Several other Tertiary vertebrate fossil localities have been identified within 1 mile of GSM's existing and proposed permit boundaries. Two Oligocene-age fossil localities have been reported in Sections 31 and 32, T2N, R3W, within the vicinity of the existing permit boundaries. These fossil locations appear to be associated with the Bozeman Group Unit. Portions of the existing tailings impoundment, access road, and drainage diversion may lie in these areas in Section 32 (GSM 1996c). Two

Miocene-age Six Mile Creek Formation fossil localities have been reported in Section 35, T2N, R4W, just west of the existing and proposed permit boundaries (Lindsey 1994). One important fossil site is located in Pleistocene-age alluvial deposits north of the existing East Waste Rock Dump disturbance boundaries in the Sheep Rock area. Pleistocene fossils, including cheetah, horse, camel, and mountain sheep have been found in this locality. This site is significant because the paleo-fauna of that period are not common to this area, and new localities could identify associations with and artifacts from Paleo-Indian cultures in the area.

III.B WATER RESOURCES

The water resources section discusses surface water and groundwater within the Golden Sunlight Mine area and vicinity. Included in the discussion are GSM water uses, supply sources, diversions and water quality and quantity in relation to the pit area, waste rock dumps, tailings impoundments, and major drainage features. The description of the affected environment for water resources was produced by reviewing literature from:

- The GSM Permit Application for an Amendment to Operating Permit 00065;
- Data contained within the GSM Operating Permit;
- Technical data, maps, and exhibits provided by the GSM staff and kept on file at MDEQ and BLM;
- Site-specific studies conducted by technical consultants for GSM and kept on file at MDEQ and BLM; and
- GSM Annual Permit Reports to MDEQ and BLM.

The data reviewed for the EIS included well drilling logs; water quality analyses; groundwater elevation measurements; aquifer test results; and geologic, topographic, and potentiometric surface maps.

Water resources within the Golden Sunlight Mine area consist of ephemeral stream channels (drainages which have occasional flow, only during winter thaws or after spring/summer storms); springs, seeps, and ponds; and groundwater that occurs within several distinct hydrogeologic units. Surface water and groundwater within the mine area generally drain to the south to the Jefferson Slough. All subdrainages at the Golden Sunlight Mine are part of the Jefferson River Drainage Basin.

III.B.1 Surface Water Resources

III.B.1.a Surface Drainages

The Golden Sunlight Mine area is located to the south and southeast of Bull Mountain on a predominately southeast dipping slope between Bull Mountain and the Jefferson Slough (Map III-4). In addition to the local drainage features shown on Map III-4, regional hydrologic drainage features are shown on maps attached in Appendix A. There are no perennial streams (streams which flow continuously) within the mine area; however, the area is drained by several well-defined ephemeral stream channels. The semi-arid climate at Golden Sunlight Mine yields a relatively small amount of annual precipitation (13 to 15 inches), as is evident by the lack of perennial streams and abundant dryland vegetation. Figure III-7 presents average monthly precipitation at Golden Sunlight Mine for the years 1991 to 1995. The precipitation data indicate maximum precipitation occurs primarily in the spring and fall.

Streamflow occurs in ephemeral stream channels throughout the mine area in response to intense precipitation events and rapid snowmelt. These events are typically infrequent and of short duration, such that some drainages may exhibit short-term runoff several times a year, whereas others may flow only once every several years. Most drainages at Golden Sunlight Mine are above the regional groundwater system and runoff rapidly infiltrates into the subsurface within channel margins to provide a source of groundwater recharge.

All ephemeral channels within the Golden Sunlight Mine area drain toward the Jefferson Slough, except for a small ephemeral drainage in the northeast portion of the area. This unnamed drainage is a small tributary of Conrow Creek, which drains to the northeast. Conrow Creek typically loses all of its water to the underlying groundwater system, but potentially can discharge into the Boulder River during extreme runoff events. However,

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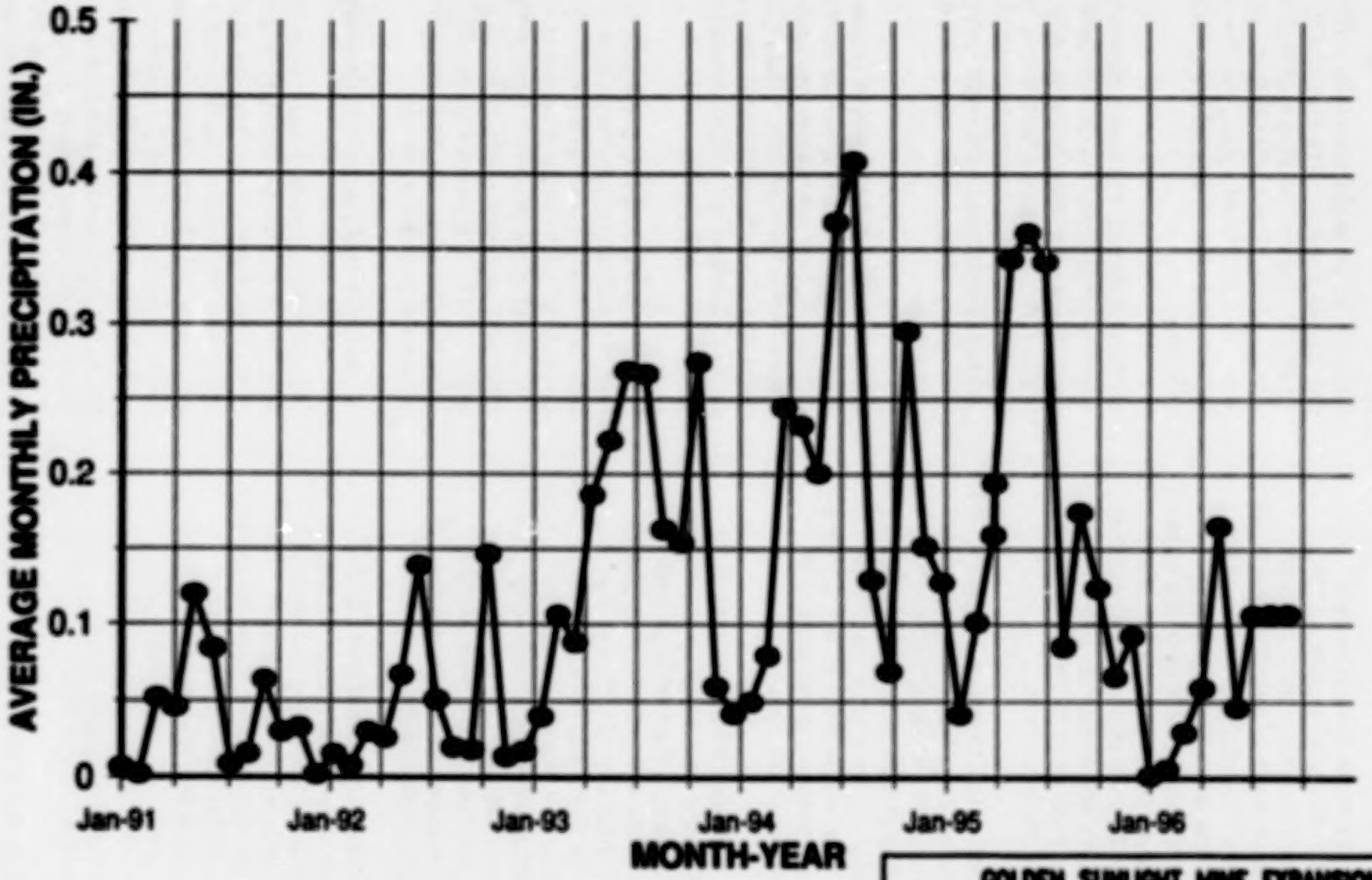

GOLDEN SUNLIGHT MINE EXPANSION

FIGURE III-7
GOLDEN SUNLIGHT MINES
AVERAGE MONTHLY PRECIPITATION

SOURCE: GSM 1996d

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discharge to the Boulder River has never been directly observed.

Sheep Rock Creek is the main ephemeral stream channel in the eastern portion of the mine area. It captures minor tributaries and drains to the south into the Jefferson Slough, as discussed above. The southern portion of the mine area contains several small ephemeral channels that originate beneath or to the north of Tailings Impoundment Nos. 1 and 2. Storm water diversion channels capture runoff north of the impoundments and direct flow into ephemeral stream channels on the east and west side of the impoundments.

The western side of Bull Mountain contains numerous small drainage features that combine to form St. Paul Gulch, which is a tributary to the Jefferson Slough upstream from the site. Two gravel trench systems in the southwest portion of the West Waste Rock Dump Complex minimize contact between spring water and waste rock material in this area.

The perennial drainages located outside of the Golden Sunlight Mine area include the Jefferson River, Jefferson Slough, Boulder River, and Whitetail Creek. The Jefferson River originates southwest of Golden Sunlight Mine at the confluence of the Ruby, Big Hole, and Beaverhead Rivers. It flows generally in a northeast direction passing approximately 1.4 miles south of the site. It is joined by the Boulder River and flows to the east, where it forms a confluence with the Madison and Gallatin Rivers to create the Missouri River.

The Jefferson Slough is located south of the Golden Sunlight Mine. It comprises an area of wetlands and marshy backwater in a braided section of the Jefferson River flood plain. The Jefferson Slough may receive ephemeral stream runoff from the Golden Sunlight Mine area during high precipitation events, primarily from Sheep Rock Creek. The slough eventually discharges into the Jefferson River, located approximately 1 mile southeast of the confluence with the Boulder River.

The Boulder River flows in a southerly direction passing 1.3 miles to the east of the Golden Sunlight Mine area and eventually discharges into the Jefferson Slough.

Whitetail Creek originates to the northwest of the Golden Sunlight Mine area and flows in a southerly direction passing approximately 3 miles to the west of the Golden Sunlight Mine area. Whitetail Creek enters into the Jefferson Slough area directly east of the town of Whitehall.

Numerous springs and seeps have been identified throughout the Golden Sunlight Mine area. Spring and seep flows typically remain on land for short distances (less than a few hundred feet) before infiltrating back into the ground. Further descriptions of springs and seeps are provided in Section III.B.2.d, Springs and Seeps.

Other surface water features at Golden Sunlight Mine include several shallow containment and settling ponds at the tailings impoundments and a pond in the open pit area. The pit pond is recharged through groundwater flow, direct precipitation, and runon from precipitation and/or snowmelt events.

Water for ore processing purposes is pumped from the tailings impoundment area, the Jefferson Slough, and the main pit. Pit water and tailings return water is routed to the operational water treatment plant located at the plant prior to its use in ore processing. Fresh water for dust suppression is supplied from Jefferson Slough and a water well located on the west side of the mine area.

III.B.1.b Surface Water Quantity

The quantities of surface water flows in and adjacent to the Golden Sunlight Mine area are highly dependent on precipitation events and snowmelt. Secondarily, springs and seeps in the area contribute to surface water flows in limited quantities. Surface water flows due to springs and seeps are directly related to and controlled by groundwater conditions. Some of these features cease flowing during dry seasons due to reduction in the water table elevations. Each of the springs and seeps identified within and adjacent to the Golden Sunlight Mine area are described in detail in Section III.B.2.d, Springs and Seeps.

The main branch of Conrow Creek drains an area of approximately 5.8 square miles. Discharge for the runoff from the 100-year, 1-hour precipitation event has been estimated at 50 cfs (GSM 1996d). The one-half PMF for Conrow Creek has been estimated at 2,756 cfs (GSM 1997).

Upper Sheep Rock Creek has a drainage area of approximately 1.2 square miles. Discharge from the 100-year, 1-hour precipitation event has been estimated at 15 cfs (GSM 1996d). The one-half PMF for Upper Sheep Rock Creek has been estimated at 976 cfs (GSM 1997).

Flow measurements have been recorded at U.S. Geological Survey (USGS) stream gaging stations on the Boulder and Jefferson Rivers since 1924 and 1978, respectively. The Boulder River has maximum, minimum, and mean discharges of 7,000 cfs, 0 cfs, and 120 cfs, respectively. A USGS stream gaging station located approximately 30 miles east of the mine area indicates that the maximum, minimum, and mean discharge at this station are 15,900 cfs, 250 cfs, and 2,421 cfs, respectively. A USGS stream gaging station, located on the Boulder River approximately 20 miles north of the site, indicates the maximum, minimum, and mean discharges are 7,000 cfs, 0 cfs, and 120 cfs, respectively.

The Jefferson River has maximum, minimum and mean discharges of 15,900 cfs, 250 cfs, and 2,421 cfs, respectively. It should be noted, however, that flow measurements at these gaging stations are not representative of flow conditions in the river near the Golden Sunlight Mine, because there are numerous inputs and outputs to and from the river between the Golden Sunlight Mine project boundary and the USGS gaging station.

III.B.1.c Surface Water Quality

Surface water samples are routinely collected by GSM at three locations on the Jefferson Slough. Sampling sites in the Jefferson Slough include one site above the Golden Sunlight Mine pumphouse (SW-3), and two sites below the pumphouse (SW-6 and SW-8). In general, all surface water sampling sites in the Jefferson Slough have historically shown low concentrations of TDS and near neutral pH. Cyanide is included in the analytical schedule for these sites, because the slough is located downgradient (south) of the tailings impoundments. Recent analyses for total cyanide have shown this parameter to be at concentrations below the analytical detection limit (<0.005 milligrams per liter [mg/L]). Sporadic detections of cyanide at these sites in the past are considered anomalous and are likely attributable to field or laboratory error, since duplicate or subsequent samples were below detection.

Several samples of storm water runoff also were collected from all three tributaries of Conrow Creek. The water quality in this area of the project is alkaline with very low concentrations of trace metals, except for aluminum and iron, which are naturally elevated. There are no recorded springs or seeps east of Sheep Rock Creek, and the only surface water that could potentially be sampled would be storm runoff from ephemeral stream drainages. Water quality data for the springs and seeps are presented in Section III.B.2.d. Water quality data for the open pit pond is described in Section III.B.2.e.

No ARD is currently discharging from the waste rock dumps. However, monitoring of conditions in reclaimed dumps shows that the waste rock has the geochemical potential to generate ARD, and that oxidation of sulfide minerals is presently occuring due to infiltration of moisture. Monitoring data suggest that a wetting front is migrating very slowly through the dumps. The slow rate of this migration is attributed in part to efforts to limit meteoric water run-on by upslope catchments and partly to geochemical reactions, which consume or dissipate water. At present, these processes appear to be effectively limiting the production of ARD at dump toes and, thereby, its potential migration and impact on the local environment.

ARD is being produced by the ore stockpile near the mill. ARD-impacted stormwater runoff from the stockpile is captured in a lined pond and routed into the water treatment plant. Effluent from the plant is used in the milling process.

III.B.2 Groundwater Resources

Groundwater occurs at the Golden Sunlight Mine area in regional and local aquifer systems comprising several hydrogeologic units. A hydrogeologic unit can be comprised of several geologic materials that have similar hydrologic properties. The units are generally connected, and groundwater movement is dominantly controlled by regional topography. The hydrogeology of the area has been characterized by evaluating data compiled from drilling investigations; well logs; water level records; aquifer test results; water quality analyses; and geologic, topographic, and potentiometric surface maps.

III.B.2.a Regional Groundwater System

The regional groundwater system at the Golden Sunlight Mine occurs in five principal hydrogeologic units. The two most important hydrogeologic units in terms of areal extent and saturated thickness are fractured bedrock consisting of the Precambrian and the Bozeman Group sediments (Map III-1, Figure III-1, and Figure III-2).

The Precambrian fractured bedrock is the primary hydrogeologic unit that occurs within and west of the Bull Mountain area. The bedrock consists of several different lithologies (rock types), which include siltstone, mudstone, sandstone, and shale containing sulfide mineralization. These sulfides are widely distributed and are easily oxidized.

Bull Mountain groundwater flow in the fractured bedrock is controlled by secondary openings such as joints, fractures, and other geologic structures, such as fault zones. The permeability of this unit is a function of the heterogenous fracture geometry (secondary porosity), rather than granular (primary) porosity. Depending on the fracture width, spacing, and orientation, some fracture systems will transmit more water than others. Bedrock permeability varies significantly on a local scale, but when examined on a more regional scale, bedrock permeability can be characterized by an average or bulk permeability. Regional analyses yield bulk bedrock permeabilities with values on the order of 10^{-4} cm/sec to 10^{-7}cm/sec, with generally lower values in deeper zones.

The Tertiary Bozeman Group is a hydrogeologic unit that occurs over the entire Golden Sunlight Mine area east and south of Bull Mountain where it overlies the bedrock unit. It is comprised of alternating layers and lenses of sand, silt, and clay deposited in a fluvial (river or stream) environment. Inspection of drill cuttings has shown fine to coarse-grained sand intermixed within clay and thin sand and gravel lenses. The discrete layers of clay, silt, sand, and fine gravel within the Bozeman unit are discontinuous due to the fluvial (river or stream) depositional environment. However, the frequency of occurrence of sand and gravel lenses suggests that these lenses are interconnected to some degree, controlling the primary permeability of the unit. The Bozeman unit typically has a low bulk permeability (2.5 x 10^{-6} to 7 x 10^{-4} cm/sec) due to the abundance of silt and clay, but it can locally exhibit relatively high permeability in sand and gravel layers and lenses.

A third hydrogeologic unit identified in the Golden Sunlight Mine area is late Tertiary to early Quaternary colluvium and alluvium that was deposited on the Bozeman unit. This unit consists of locally derived gravels in a silty sand matrix that also may include reworked Bozeman Group sediments and older (Tertiary) fan terrace deposits consisting of sand, gravel, and clay. Younger alluvial material (sand and gravel) found in modern drainages throughout the proposed disturbance boundary area also is included with this unit, since it shares similar textural characteristics with the older deposits. This unit is thickest adjacent to the present East Waste Rock Dump area on the east side of Bull Mountain and thins to the south and east. The colluvial/alluvial unit does not have a significant saturated thickness, but appears to contain discontinuous, fine-grained lenses (generally less than a few feet in thickness), which may become partially or fully saturated from infiltration of precipitation falling directly over these areas and/or from recharge from adjacent hydrogeologic units.

A fourth hydrogeologic unit in the mine area is comprised of debris flow/colluvial materials. This unit is present in localized areas on the east side of Bull Mountain and is most important in Rattlesnake Gulch in terms of areal extent and saturated thickness. Depending on location, the unit may be exposed at land surface or overlain by recent alluvium and colluvium.

The fifth hydrogeologic unit in the Golden Sunlight Mine area is alluvium associated with the Jefferson River hydrologic system. This unit occurs along the southernmost proposed disturbance boundary area and is in contact with and receives groundwater from the Bozeman unit. The direction of groundwater flow in the Jefferson River alluvial unit is to the east.

Groundwater elevation data were used to develop a regional potentiometric map of the mine area for late season 1990 conditions (Map III-6). The contours are generalized because they are based on groundwater elevations from wells screened at different depths and in different hydrogeologic units. The contours are intended to be used as an approximate indicator of regional groundwater flow direction and bulk permeability. The 1990 measurements can be considered representative of present conditions, since groundwater elevations do not vary significantly from year-to-year. Some variation in groundwater flow direction may occur on a localized scale due to localized recharge-discharge relationships and permeability.

Water levels from shallow-deep well pairs indicate that there is a downward component to groundwater flow. This is consistent with a typical hydrogeological model where regions of high topographic relief are the primary groundwater recharge sources to aquifers in low-lying areas. Most groundwater recharge occurs during the spring and early summer when snowmelt and rainfall runoff are greatest. Groundwater generally flows to the southeast, south, and southwest from the high topographic relief of Bull Mountain bedrock to lower elevations where the Bozeman Group sediments comprise the predominant hydrogeologic unit. Groundwater flow is primarily to the southeast in the Bozeman Unit.

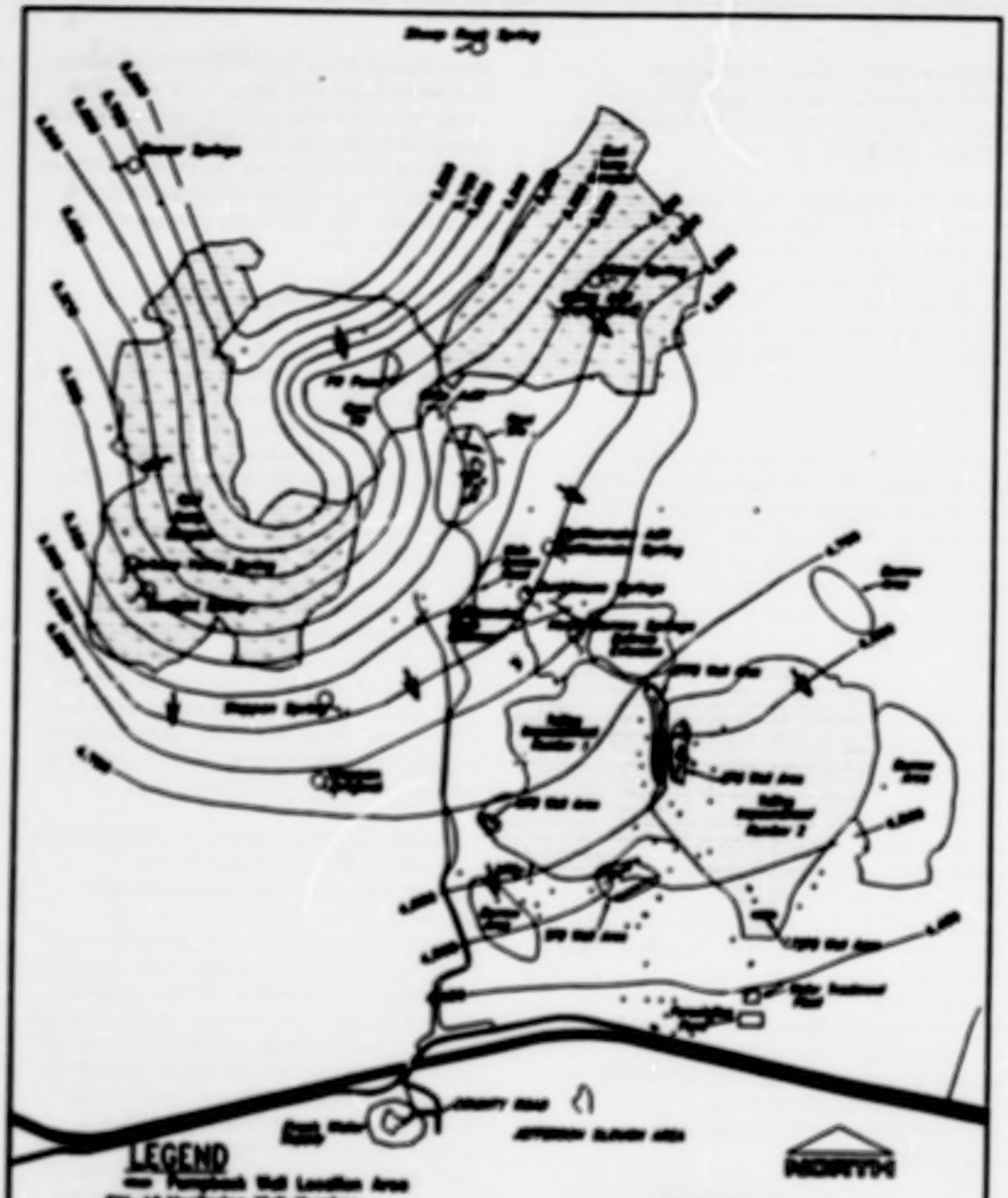
III.B.2.b Groundwater Quality

Groundwater quality in the Golden Sunlight Mine project area is characterized from selected wells chosen to be representative of conditions within major hydrogeologic units. Appendix B contains summary tables of water quality data, and statistical relationships for the project area.

The groundwater quality of the Golden Sunlight Mine project area is highly variable. Groundwater within the project area on the east side of Bull Mountain (east waste rock area and tailings impoundments) occurs primarily in the Bozeman unit. Water quality in this unit ranges from good to poor with TDS between 300 to 2,000 mg/L, depending on the location in the project area. In general, water quality is better and the TDS is lower in the northern portion of the Golden Sunlight Mine project area.

Bozeman unit groundwater is generally a mixed type with calcium and sodium as the predominant cations and bicarbonate and sulfate as the major anions. The pH of Bozeman unit groundwater is generally neutral to slightly alkaline, and metals are at or below detectable concentrations. Nitrate values are generally in the 1.0 to 2.0 mg/L range, although higher values have been measured in localized areas to the south that reflect past agricultural use of the area. Groundwater quality in the Bozeman unit directly adjacent to Tailings Impoundment No. 1 shows detectable levels of total cyanide and slightly elevated TDS values indicative of seepage from the impoundment.

Although waters issuing from springs within the Midas, Stepper, Stepper Original, and Rattlesnake Gulch areas (see discussion in


LEGEND
Pumpback Well Location Area
PW-10 Monitoring Well Number and Location
GW-7 Abandoned Monitoring Well Number and Location
Adit
Spring
5,000 Potentiometric Contour Line (Dashed Where Inferred)
Inferred Direction of Groundwater Flow
NORTH
COUNTY ROAD
JEFFERSON SLOUGH AREA

GOLDEN SUNLIGHT MINE EXPANSION

MAP III-5

GENERALIZED POTENTIOMETRIC MAP
LATE SEASON 1993

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Section III.B.2.d) show characteristics of ARD, groundwater quality in the Bozeman unit directly downgradient of these areas does not show characteristics of ARD. Groundwater monitoring data indicate that water quality changes and the attenuation of ARD constituents occur, as naturally acidic groundwater from Bull Mountain flows eastward and interacts geochemically with the calcareous soil matrix of Tertiary and younger deposits. The observed changes in groundwater chemistry are likely attributed to a combination of attenuation mechanisms such as pH buffering, mineral precipitation, adsorption, and dispersion phenomena.

The groundwater quality of the bedrock unit is generally poor with high sulfate values and TDS of over several thousand milligrams per liter. The predominant cation in bedrock unit groundwater is magnesium, although high percentages of calcium and sodium occur in some areas. The major anion in bedrock groundwater is sulfate. The pH of this groundwater is generally neutral to acidic, with several metals above detectable concentrations. In general, the groundwater in the bedrock unit in the mineralized area of the project site appears to have lower pH and higher sulfate values than groundwater in the less mineralized portion of the project area.

Table III-1 summarizes groundwater quality data from Appendix B. These data are grouped into 8 regions within the project area. Geometric mean values of TDS range from 318 to 1,549 mg/L and sulfate ranges from 55 to 646 mg/L. TDS and sulfate mean concentrations are lowest east of the mine pit and are highest in the treated discharge percolation pond area. Ambient groundwater quality in the areas west and southwest of the Tailings Impoundment No. 1, southeast of the pit, and south of the SP8 well area is considered fair with geometric mean values for TDS ranging from 731 to 1,153 mg/L and sulfate values ranging from 345 to 439 mg/L. The geometric mean pH of ambient groundwater in the eight regions is generally neutral with the exception of the area southeast of the pit which is acidic with a pH of 4.3. Nitrate/nitrite geometric mean values are all below 1 mg/L except for the area near the treated discharge percolation pond which has a mean value of 23.6 mg/L. Metals concentrations in the ambient groundwater are generally at or below detection limits.

III.B.2.c Local Groundwater System

Localized groundwater systems occur at the Golden Sunlight Mine in areas where interflow and artificial recharge/discharge is prevalent. Interflow likely occurs in alluvium drainages after precipitation events and in areas where excavations have intercepted perched water-bearing units above the regional water table. Interflow generally has a predominantly lateral flow direction due to underlying less permeable layers. The groundwater may discharge at the surface or may remain in local aquifers until it is lost to evaporation/transpiration or eventually percolates downward to recharge the regional water table. Surface expressions of localized groundwater systems are often short-lived springs and seeps. Localized groundwater also can increase ephemeral stream flows by discharging through channel margins during and after precipitation events. At the Golden Sunlight Mine, there are several depressions and incised channels within highly permeable units that are likely areas for local groundwater discharge and recharge. For the most part, incised drainages at the Golden Sunlight Mine occur above the regional groundwater system and are sources of regional groundwater recharge from runoff and infiltration.

Mine-related activities have created a localized groundwater system in the tailings area due to artificial recharge and discharge. A groundwater mound has been created at the Tailings Impoundment No. 1 area due to the introduction of saturated tailings over the years. This water infiltrated into the subsurface to create a groundwater mound where flow was radially to the east, south, and to the southwest. This mound was superimposed on the regional gradient, which is to the southeast at this location.

Additionally, interception/pumpback wells have been constructed in this area, which further affect the potentiometric surface by reversing

Table III-1

Ambient Groundwater Quality (geometric mean in mg/L)

Parameter	East of No. 2 Impoundment	East of Mine Pit	South of SPB Well Area	South of No. 2 Tailings Pumpback Area	Southeast of Mine Pit	Southwest of No.1 Tailings Impoundment	West of No.1 Tailings Impoundment	Treated [illegible] Pond Area
pH (field)	7.1	7.1	7.1	7.2	4.3	6.9	7.0	7.1
TDS	382	318	679	578	731	1153	885	1549
sulfate	96	55	437	280	439	390	345	648
NO_2+NO_3	0.48	0.63	0.31	0.29	0.56	0.21	0.28	23.6
aluminum	0.1	0.1	0.094	0.1	6.5	0.112	0.108	0.1
antimony	0.0039	0.0034	0.004	0.005	0.003	0.003	0.0039	nd
arsenic	0.024	0.015	0.009	0.013	0.005	0.007	0.004	0.005
barium	0.043	0.068	0.024	0.066	0.054	0.058	0.042	0.1
beryllium	0.001	0.001	0.001	0.001	0.0028	0.001	0.001	nd
cadmium	0.0003	0.0012	0.001	0.0002	0.0036	0.0005	0.0004	0.001
copper	0.004	0.007	0.013	0.006	0.434	0.0089	0.0067	0.018
chromium	0.0012	0.006	0.0012	0.001	0.0037	0.004	0.0013	nd
iron	0.02	0.048	0.054	0.023	0.225	0.04	0.039	0.03
lead	0.0026	0.0085	0.005	0.002	0.0085	0.007	0.0034	0.01
manganese	0.012	0.029	0.041	0.005	0.681	0.035	0.084	0.012
mercury	0.0005	0.0007	0.0006	0.0002	0.0008	0.0009	0.0006	nd
nickel	0.014	0.013	0.018	0.011	0.098	0.011	0.017	nd
selenium	0.0022	0.0032	0.004	0.004	0.0031	0.005	0.0012	nd
silver	0.002	0.004	0.0025	0.0005	0.0042	0.0044	0.0032	0.005
thallium	0.0026	0.003	0.0024	0.002	0.003	0.003	0.003	nd
zinc	0.046	0.052	0.048	0.037	0.542	0.04	0.038	0.089

nd = no data for this parameter.

Below detect values replaced by the detection limit for calculation.

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gradients due to groundwater extraction. The local groundwater system in the tailings impoundment area is detailed more completely in Section III.B.2.f, *Groundwater in the Tailings Impoundment Areas*. The locations of groundwater wells are shown on Map III-4.

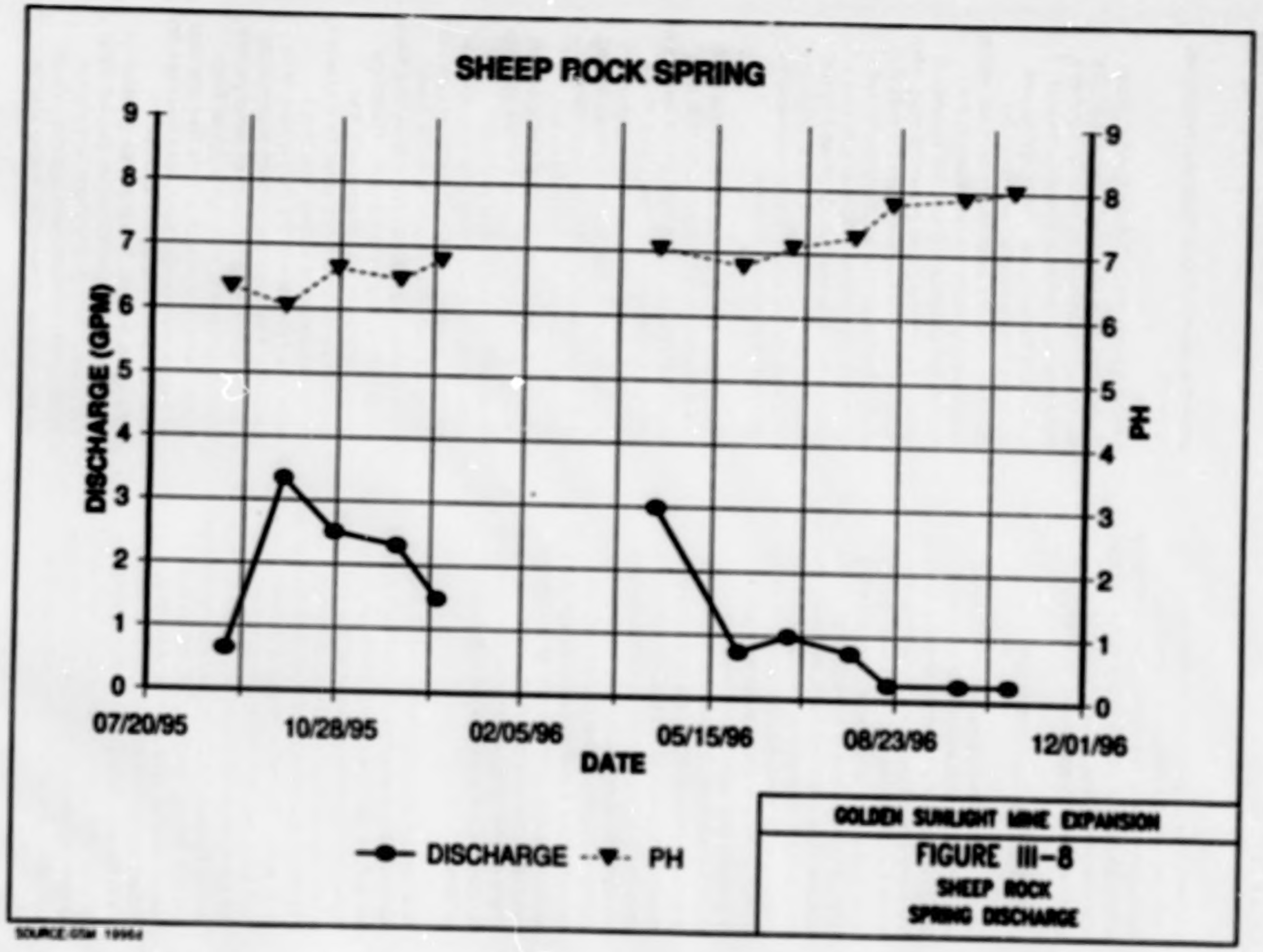
III.B.2.d Springs and Seeps

Several springs and seeps occur within and adjacent to the Golden Sunlight Mine area. Map III-4 shows the locations of these features. There are several geological conditions that can create these features. At the Golden Sunlight Mine, spring and seep formation is likely the result of one or more of the following: 1) the regional water table intersects an abrupt change in the surface topography, usually at the base of a hillside or in localized depressions such as incised drainages (depression springs); 2) groundwater within a permeable unit becomes perched on a less permeable unit, directing it laterally along the contact until it eventually appears at the land surface (contact springs); 3) fractures within bedrock transmit groundwater under hydrostatic pressure to surface outcrops, or into alluvial/colluvial material where it eventually appears at the land surface (fracture springs); and 4) abandoned/collapsed adits intersect the regional potentiometric surface and provide conduits for the discharge of groundwater to the land surface.

Most springs and seeps within the Golden Sunlight Mine area generally discharge only a few gallons per minute, and some can cease flowing during dry seasons when the water table is low. Beaver Springs, on the other hand, are well-developed springs with reported flows of up to 25 gpm. The major springs and seeps that have been mapped within and adjacent to the Golden Sunlight Mine area include Sheep Rock Spring, Rattlesnake Spring, Bunkhouse Springs, Steppan Spring, Steppan Original Spring, Beaver Springs, and an unnamed spring. Surface seeps formerly existed in the Midas, North Borrow, Sunlight, and Arkose Valley Spring areas, but have since been intercepted by drain systems to allow placement of waste rock piles. The drains were constructed to prevent contact between water and waste rock materials.

Several springs in the Golden Sunlight Mine project area have chemical compositions that are strongly influenced by ARD-like solutions and some have elevated concentrations of sulfate and trace metals. These springs are considered to be natural because of the abundant ferricrete associated with them, which requires many years to accumulate to the thicknesses observed. (Ferricrete consists of surficial sands and gravel cemented into a hard mass by iron oxide derived from the oxidation of sulfide minerals into solutions of iron salts.) The presence of these long-term acid seeps indicate that ARD has been produced by Bull Mountain for some time and that the rock that comprises Bull Mountain and is excavated from the open pit readily forms ARD.

Sheep Rock Spring occurs within Sheep Rock Creek, northeast of the east waste rock area and approximately 1 mile from the pit boundary where it originates in the Sheep Rock Creek ephemeral stream channel near a bedrock outcrop. It is likely that the spring is recharged by both precipitation runon to upper Sheep Rock Creek that is then perched on the bedrock, as well as fracture flow that outcrops beneath the alluvium. A portion of the spring is intercepted by a catchment structure constructed by a local rancher and is used for livestock watering. Figure III-8 presents periodic discharge and pH measurements for Sheep Rock Spring. Discharge data indicate that flows range from 0.25 gpm to 3.4 gpm. Discharge measurements do not reflect spring flow captured by the catchment structure upgradient of the measurement station. Discharge variations expressed in the data appear to be seasonal. This seasonal variation supports the concept that the spring receives recharge from precipitation events from upper Sheep Rock Creek. Data also suggest a base flow rate near 0.25 gpm, which likely is a contribution from the regional water table via the bedrock hydrogeologic unit. The presence of sulfate in the spring water is an indication that the water has passed through a bedrock formation in which sulfide minerals have oxidized. Water quality data for Sheep Rock Spring indicate



GOLDEN SUNLIGHT MINE EXPANSION

FIGURE III-8
SHEEP ROCK
SPRING DISCHARGE

SOURCE: GSM 1996d

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concentrations of sulfate on the order of 170 ppm.

Rattlesnake Spring is located southeast of the plant site along Rattlesnake Fault. The spring discharges from the side of an ephemeral stream channel near the abandoned Rattlesnake Adit. The spring is believed to originate in the adit (GSM 1995b). Discharge measurements (Figure III-9) indicate a relatively constant base flow of 0.2 to 0.6 gpm. Some variation in the data is likely associated with measurement error. The pH is slightly acidic, and sulfate concentrations range from 309 to 359 ppm indicating the groundwater was in contact with mineralized zones within Rattlesnake Gulch. Rattlesnake Adit likely transmits groundwater from the Bozeman hydrogeologic unit, which also receives regional groundwater from Rattlesnake Gulch and possibly the upgradient bedrock hydrogeologic unit. The relatively constant base flow and lack of seasonal variation indicate that Rattlesnake Spring is an expression of the regional groundwater system.

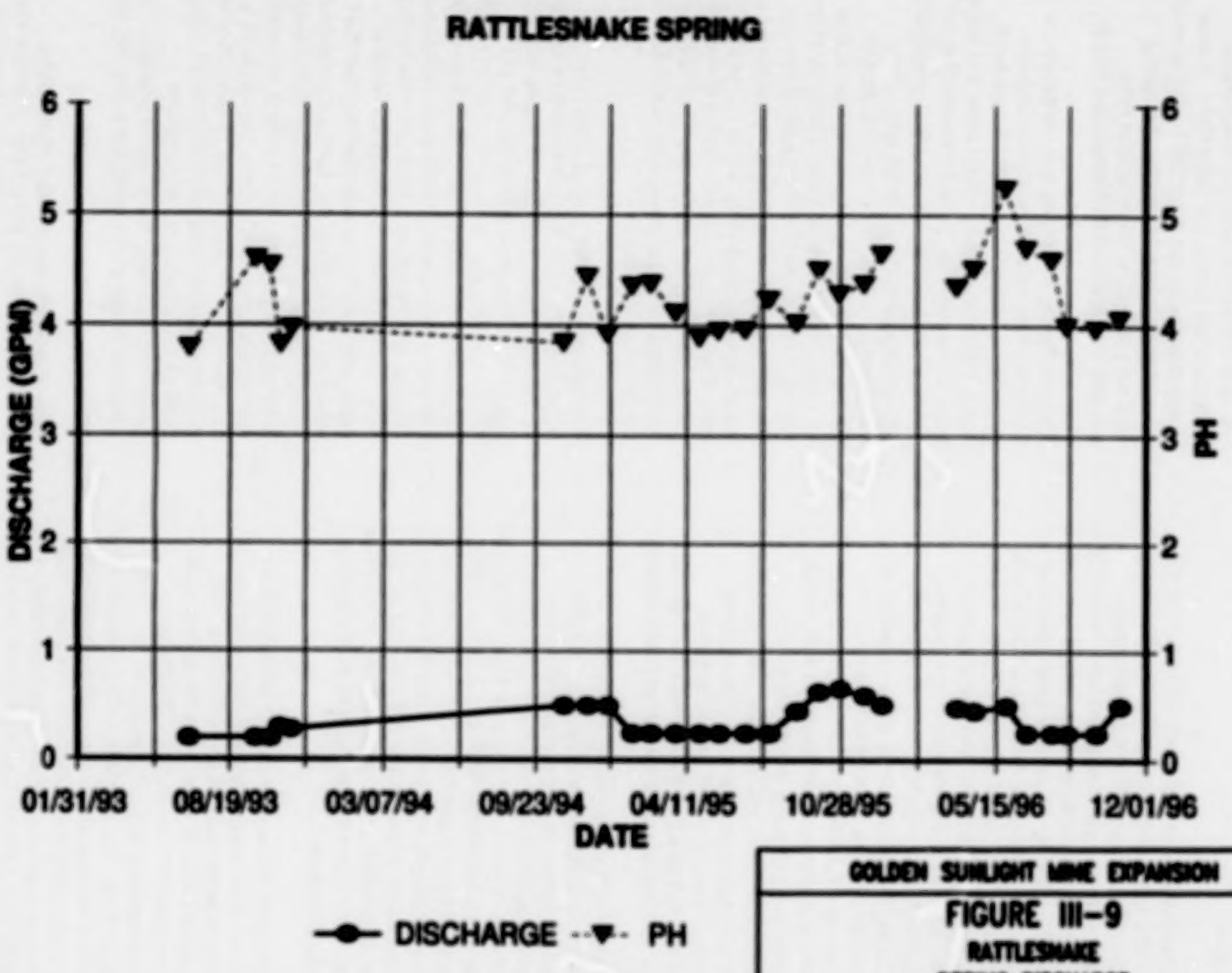
Bunkhouse Springs are located to the southwest of Rattlesnake Spring near the southern extent of a large landslide block (Rattlesnake Block). The Bunkhouse Spring North has been developed and flows through an area of approximately 30 feet by 30 feet that is characterized by ponded water, saturated soil, and hydrophytic vegetation. The Bunkhouse Spring South appears intermittently below the area of ponded water and saturated soil, where water from the main spring area re-emerges at the land surface.

Bunkhouse Springs occur within debris flow material and appear to be surficial expressions of the regional water table in the area. The combined flow of water from the spring area varies from 0.75 to 7 gpm. Discharge measurements and pH are plotted in Figure III-10. These springs may originate due to the presence of discrete high permeability conduits within the colluvium. Discharge data indicates a perennial flow of approximately 1 to 2 gpm with some variability, likely in response to precipitation events. The perennial, relatively constant nature of the flow indicates the spring reflects the regional groundwater system. The discharge response to precipitation events indicates the spring receives some direct recharge from runon and infiltration. Sulfate concentrations range from 598 to 733 ppm and pH is slightly acidic, indicating the spring receives some flow contributions from mineralized zones within Rattlesnake Gulch.

Steppan Spring originates from bedrock fractures in an ephemeral stream channel southeast of the existing West Waste Rock Dump Complex. Spring water from this source flows into a small ephemeral stream channel before infiltrating into the ground approximately 100 yards from where it originates. Flow measurements (Figure III-11) indicate that discharge from the spring varies from 0.2 to 1.4 gpm. The drainage basin above Steppan Spring is quite small. Consequently there is little potential for the spring to receive any substantial recharge from storm runon and infiltration. The pH values indicate the water is acidic, and elevated sulfate levels (1,760 to 9,170 ppm) reflect contact with mineralized zones in the bedrock.

The Steppan Original Spring, located approximately 1,600 feet southwest of Steppan Spring flows from a collapsed abandoned adit. Figure III-12 presents discharge and pH measurement data. Discharge measurements range from 0.75 to 2.74 gpm. It is believed that imprecisions associated with the measurement process largely account for the variations in the data. Consequently, the Steppan Original Spring appears to have a relatively constant flow rate. Variation in the spring discharge in response to runon and infiltration is not evident in the discharge data. The pH is fairly neutral with sulfate concentrations in the range of 1,790 to 2,200 ppm. The relatively constant flow rate and the elevated sulfate concentrations indicate the adit likely intercepts the regional groundwater, which has traveled through mineralized zones in the bedrock hydrogeologic unit.

Beaver Springs are located north of the northwest corner of the Golden Sunlight Mine area, at approximately 5,600 feet, and have been developed for livestock use. The springs lie on the St. Paul Gulch side of the



GOLDEN SUNLIGHT MINE EXPANSION

FIGURE III-9
RATTLESNAKE
SPRING DISCHARGE

SOURCE: GSM 1996d

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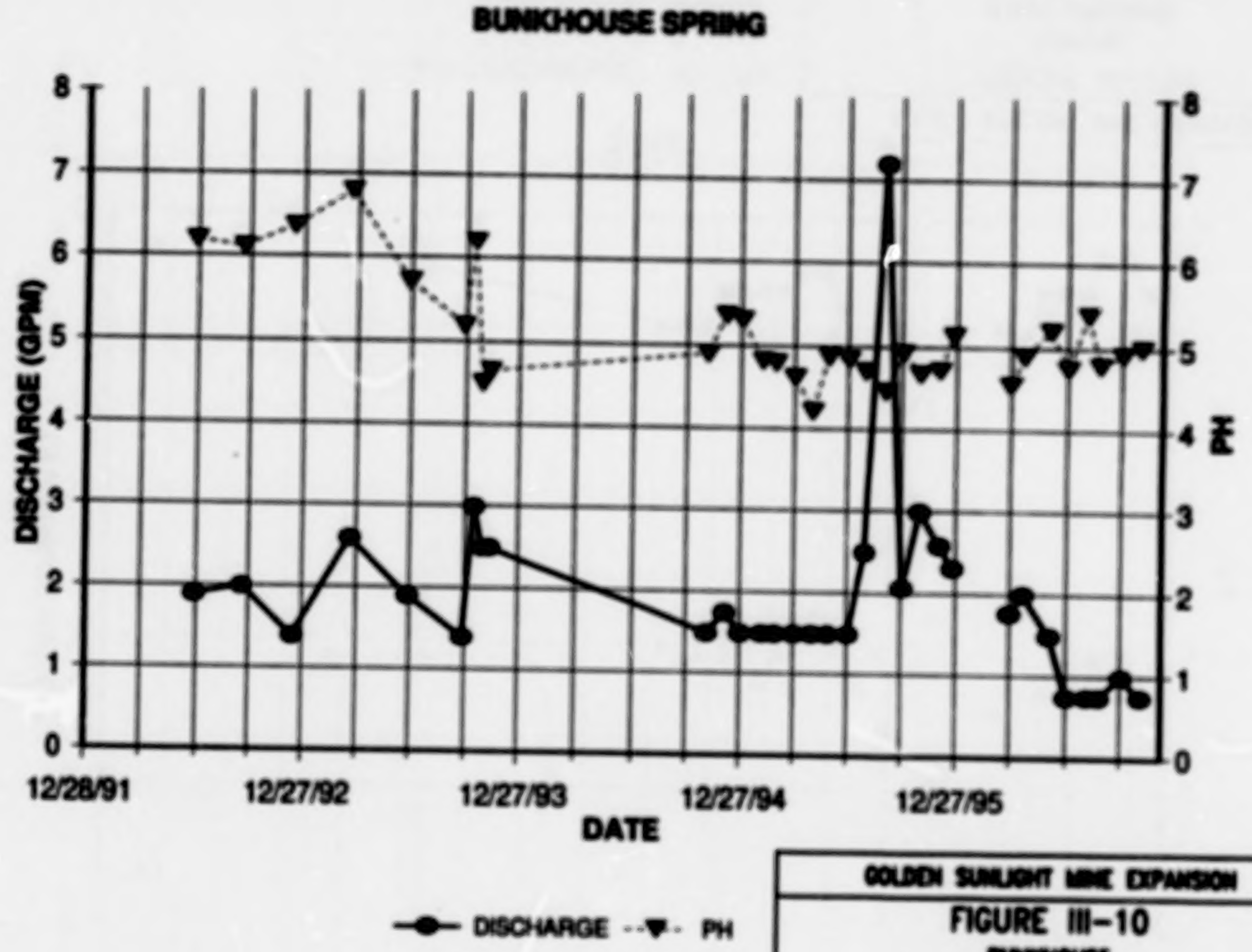

GOLDEN SUNLIGHT MINE EXPANSION

FIGURE III-10
BUNKHOUSE
SPRING DISCHARGE

SOURCE: GSM 1996d

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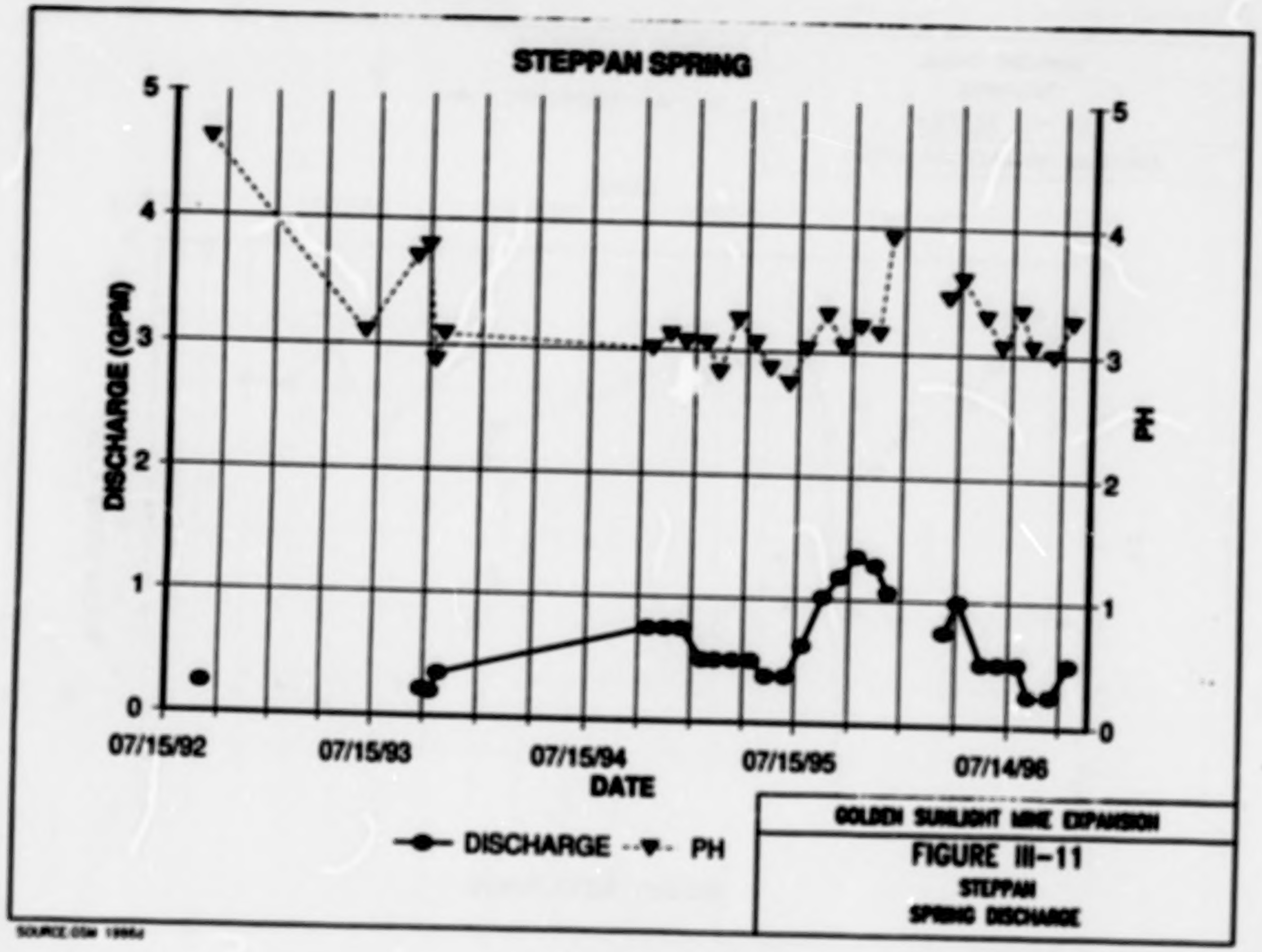

GOLDEN SUNLIGHT MINE EXPANSION

FIGURE III-11
STEPPAN
SPRING DISCHARGE

SOURCE: GSM 1996d

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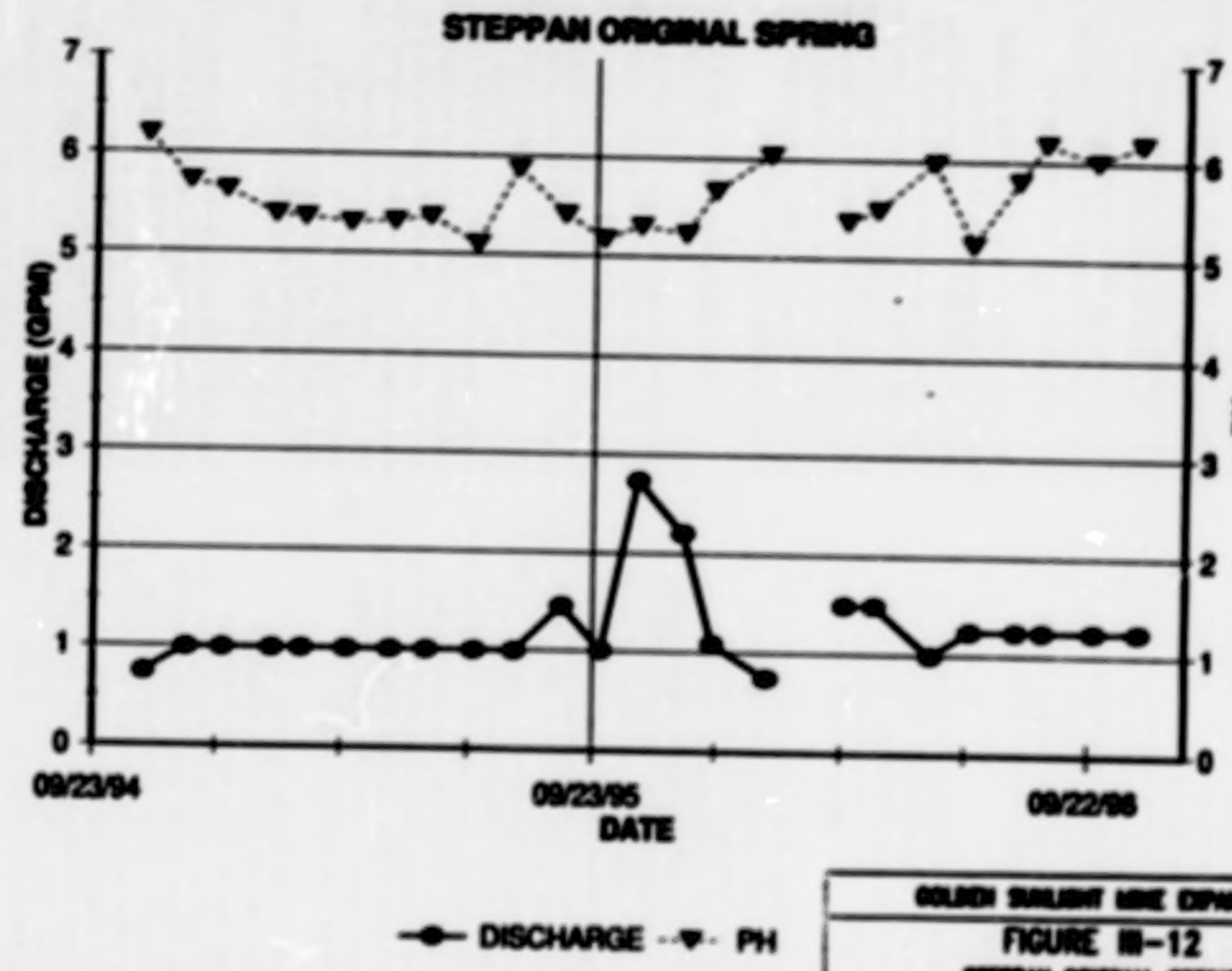

GOLDEN SUNLIGHT MINE EXPANSION

FIGURE III-12

STEPPAN ORIGINAL SPRING

SPRING DISCHARGE

SOURCE: CSM 1996a

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groundwater divide. This development consists of a large steel culvert collection basin where water is diverted through plastic piping to a discharge point. The water then flows into an ephemeral stream channel for approximately 100 feet before it infiltrates into the ground. Discharge measurements are typically in excess of 8 gpm; flows have been reported as high as 25 gpm and as low as 1 gpm. More information is required to adequately classify Beaver Springs. Variable flow rates indicate the spring may respond to water table fluctuations and that discharge may be affected by variations in groundwater levels.

Little information is available for the unnamed spring located on a tributary to St. Paul Gulch (Map III-4). The spring is located outside the GSM property boundaries and has not been sampled historically for water quality or flows.

The former Midas Spring occurred in an active dump area now covered by the East Waste Rock Dump. Historically, the spring was intermittent and did not always emerge from the same location, probably due to the changing hydraulic conditions within the dump. The source of this water is still uncertain, but could be the result of discharge from the abandoned Midas Adit, which is now covered by waste rock. The drainage above the dump (to the west) may provide a catchment area for precipitation, which infiltrates into the ground and is directed into the dump, re-emerging as a contact spring. Water from the former Midas Spring is presently intercepted and conveyed by pipeline to the Golden Sunlight Mine mill facility. Flow measurements taken from the discharge line average approximately 3 gpm.

The former North Borrow Springs, located approximately 120 yards north of Tailings Impoundment No. 1, consisted of a broad seepage area with flow rates ranging from 8 to 32 gpm. These springs were created when the North Borrow Area was excavated below the shallow water table. Spring water is now being intercepted by an underdrain system constructed beneath the buttress waste rock pile. The system conveys water by pipeline to Tailings Impoundment No. 2. The North Borrow Area excavation has recently been filled with material from the East Waste Rock Dump.

The former Sunlight Spring was located near the southeast section of the West Waste Rock Dump Complex. Discharge from the spring has historically ranged from 0 to 6 gpm, flowing down a narrow channel for approximately 100 yards before infiltrating into the ground. The spring is currently covered by a gravel trench system that minimizes contact between the spring water and waste rock material.

The former Arkose Valley Spring was located northeast of the former Sunlight Spring. Historically, the spring has averaged less than 1 gpm, flowing approximately 80 yards before infiltrating into the ground. The spring area also is covered by a gravel trench system (drains) to allow placement of waste rock. The drains were construction to intercept the Arkose Valley Springs and prevent contact between spring water and waste rock materials.

III.B.2.e Groundwater in the Pit Area

The Golden Sunlight Mine open pit is located east of a major hydrologic divide that coincides with a topographic ridge oriented north-south along the southern portion of Bull Mountain. Groundwater in the vicinity of the pit occurs as part of a regional groundwater system that flows south, east, and west from the hydrologic divide. Groundwater also occurs locally by infiltration of precipitation within and adjacent to the pit perimeter. Groundwater in the pit area discharges to springs and seeps emerging from the pit walls and to the underlying bedrock and unconsolidated (Tertiary and Quaternary) hydrogeologic units. Faults and fracture systems control the permeability of the bedrock unit in the pit area.

The open pit is centered around a hydrothermal breccia pipe that cuts through the bedrock hydrogeologic unit. The pit is bounded to the east by a north-south trending range-front fault. The Corridor Fault (formerly referred to as the "Rumpled Zone") is probably the most important fault present in the pit area with regard to hydrogeology. The Corridor Fault is actually a zone up to several hundred feet wide of low-angle, extensional faulting that dips to the northeast. Other dominant structural features in the pit area consist of a series of northeast-trending high-angle faults, which are truncated to the west and at depth by the low-angle Corridor Fault.

The present hydrologic model assumes that regional groundwater flux and local recharge in the pit area are intercepted by high angle structures, which transmit water preferentially along fractures with high permeabilities. These high-angle structures are intersected and offset by the younger low-angle Corridor Fault. The Corridor Fault is probably recharged in part, by the high-angle structures, and provides an additional high-permeability conduit that transmits groundwater to the pit in a fault zone over 100-feet-wide. The fault zone transects the pit at a highwall (approximately 5,800 feet in elevation) and extends to the bottom of the north highwall in the pit area (approximately at the 5,225-foot elevation). The present pit floor (approximately 5,225 feet) is slightly below the regional water table elevation.

The relatively high permeability of the Corridor Fault is suggested by the occurrence of numerous seeps within a broad area of the fault along the north high wall. The combined discharge from the seeps has been visually estimated to be between 5 and 15 gpm. Although the discharges from several of these seeps appear to be perennial, flows fluctuate in response to precipitation events. This suggests that the seeps along the exposed Corridor Fault originate from both regional groundwater flux and localized precipitation recharge.

Permeability testing was conducted in 1983 by Hydrometrics, Inc. (1985) using monitoring well R-15 constructed to a depth of 1,000 feet in the pit. The well was sited to intercept the high-angle Lone Eagle Fault that would contact the proposed pit wall. A hydraulic conductivity of approximately $1x10^{-7}$ cm/sec was interpreted from the test data. These results suggest that the transmissivity of the bedrock is 1 to 2 orders of magnitude lower at the base of the pit than at shallow depths.

Wells PW-7 (now abandoned) and PW-12 on each side of the Golden Sunlight Fault showed an abrupt drop of 120 feet in potentiometric surface across the fault (in the downgradient groundwater flow direction), which indicates a strong permeability contrast at the fault. It is assumed that some groundwater from the pit area is conveyed to the south along fractures associated with the Golden Sunlight Fault system. However, the majority of groundwater from the pit area is believed to discharge primarily to the Tertiary and Quaternary deposits east of the pit.

The regional potentiometric map shows a groundwater divide beneath the ridge immediately west of the pit. Groundwater east of the divide flows away from pit. Potentiometric contours wrap around the pit area indicating that groundwater levels are depressed beneath the pit. This likely reflects dewatering of the former Ohio Adit, as well as the effects of seepage into the open pit. Measurements of pit sump pumping and discharge from the Ohio Adit suggest that groundwater flux just beneath the present pit area varies between 6 and 25 gpm.

The former Ohio Adit was located east of the open pit. The adit was extended beneath the present pit bottom in the late 1970s for mineral exploration purposes. The adit created an effective drain in the pit area due to ring-drilling that intersected water-bearing fractures. Discharge from the Ohio Adit ranged from approximately 6 to 25 gpm and was intercepted by a collection system that directed flow to the mill facility. The Ohio Adit was destroyed in early 1994 when it was intersected by mining in the open pit. The former adit now intersects the west side of the pit wall and discharges into the pit. Pit water is collected and routed to the operational water treatment plant located in the mill facility.

Water quality data obtained for the pit pond, the Ohio Adit, and highwall seeps show them to be high in magnesium-sulfate, high in TDS, elevated with dissolved metals, and have a low pH. Water from wells adjacent to the pit varies considerably in pH, TDS, and dissolved metals concentrations.

Water entering the Golden Sunlight Mine open pit collects on the floor in a small sump. The sump water contains elevated sulfate, TDS, and metals concentration along with depressed pH, characteristic of ARD. Sulfide minerals exposed in the walls of the open pit that occur in previously unoxidized material are most certainly oxidizing at present. However, owing to limited amounts of water available while dewatering activities are occurring, the oxidation products may not be mobilized in solution as ARD.

III.B.2.1 Groundwater in the Tailings Impoundment Areas

Hydrogeologic Environment in the Vicinity of the Tailings Impoundments

The tailings impoundment area is located above two main hydrogeologic units. The major unit in terms of areal extent and thickness is the Bozeman unit. The other unit, which is very localized but important, is recent colluvium/alluvium comprised primarily of sand and gravel that occurs in modern drainages generally trending north to south.

The Bozeman unit has thin permeable sand and gravel lenses that are believed to be laterally and vertically interconnected in a matrix of less permeable sediment. Groundwater movement is dominantly controlled by regional topography, with localized influence from Tailings Impoundment No. 1 and intercept/pumpback wells.

The potentiometric surface is influenced by three hydraulic regimes in the tailings impoundment areas. First, there is the primary regional groundwater flow gradient toward the southeast. Superimposed on this is a gradient created by the Tailings Impoundment No. 1 groundwater mound, which flows radially toward the east, south, and southwest. This mound will eventually subside as the tailings drain over time. Superimposed on both the regional and impoundment gradients are the gradients created by the pumpback wells east and south of the impoundment. The pumpback wells represent groundwater sinks (discharge areas) and create groundwater depressions from extended pumping.

The colluvium/alluvium unit occurs in recent ephemeral stream channels, which originate beneath or to the north of the tailings impoundments area. One of these drainages originates beneath Tailings Impoundment No. 1 and extends due south of the impoundment in the South Pump Back (SPB) well area which is shown on Map III-4. Tailings Impoundment No. 1 was constructed without a synthetic liner. A bentonite slurry cut-off wall was constructed across the alluvial channel south of the impoundment embankment to contain groundwater beneath the tailings impoundment. A smaller alluvial drainage feature that has historically contained groundwater exists along the west side of Tailings Impoundment No. 2, and extends to the southeast, beneath the main embankment and into the T2PB well area (Map III-4). This hydrogeologic unit is now covered by the liner of the No. 2 impoundment and is believed to have been truncated by excavation of the west reclaim basin (a seepage collection basin) and associated overflow ponds south of the impoundment.

Historic Seepage from Tailings Impoundment No. 1

A deficiency in the slurry cut-off wall below Tailings Impoundment No. 1 allowed groundwater and seepage from the impoundment to migrate southeast, past the barrier within the alluvial channel. This seepage was detected during routine groundwater sampling in April 1983. GSM immediately began remedial activities by making repairs to the slurry wall, and by constructing pumpback wells (SPB wells shown on Map III-4) upgradient and downgradient of the cutoff wall. The first row of SPB wells was constructed in 1983, and the second and third rows of SPB wells were constructed primarily in 1990 and 1991, respectively.

Presently, the groundwater table near the first row of SPB wells occurs within the alluvial unit occupying the modern drainage. Pumping associated with the second and third row of SPB wells eventually dewaters the alluvium, and the water table is drawn down into the Bozeman unit, which intersects the Jefferson River alluvial unit.

In 1984, rising groundwater levels and concentrations of cyanide indicative of tailings seepage were detected in groundwater monitoring wells located adjacent to the northeast corner of Tailings Impoundment No. 1. Several interception/pumpback wells were constructed in the East Pump Back (EPB) well area shown on Map III-4 to collect this seepage, but cyanide concentrations in groundwater increased over time in an area near the center of the EPB well network. Two factors are believed responsible for locally elevated cyanide. One is the presence of sand and gravel lenses, which convey groundwater from the tailings impoundment to the Bozeman unit. Second is the increase in hydraulic gradients created by continuous pumping of the EPB wells that induced seepage to flow preferentially toward the area of the wells.

A series of additional pumpback wells were constructed along the East Flank Pump Back (EFPB) well area of Tailings Impoundment No. 1 beginning in 1990 to further mitigate and allow gradual decommissioning of the older EPB wells. Water quality in the groundwater monitoring wells east of Tailings Impoundment No. 1 improved between 1990 and 1991, due to the effects of the EFPB well system. The present areal extent of the plume within the Bozeman unit is generally limited to within 600 to 800 feet of the impoundment along its east and southeast flanks.

Historic Leakage from Tailing Impoundment No. 2 East Reclaim Pond

Tailings Impoundment No. 2 has a synthetic liner to prevent seepage from the tailings into the underlying materials. The liner is a 60 mil, high density polyethylene (HDPE) geomembrane that extends under the toe berm, the starter dam, and the impoundment. The foundation for the liner was prepared by excavating and recompacting the top 15 feet of soil material to form a dense, less permeable base. Water draining from tailings in Impoundment No. 2 is collected by drains on top of the geomembrane liner, and is conveyed into the reclaim ponds below the impoundment. Reclaim water is then recycled back to the mill complex ore processing circuit.

A double-liner system comprising two, 60 mil HDPE geomembranes was originally built under the reclaim basins. This system was connected to the single liner underlying the tailings impoundment to form a continuous liner. The primary and secondary liners under the reclaim ponds are separated by an HDPE drainage net. The intent of this design is to allow detection of any leakage from the primary liner, and to convey the leaking fluids to leak detection sumps which are monitored.

Since 1995, cyanide has been detected intermittently in groundwater in several T2PB monitoring wells downgradient of the Tailings Impoundment No. 2 reclaim ponds. Intermittent detections were typically just above the laboratory detection limit of 0.005 ppm. The area around the reclaim basins was investigated in 1995 and 1996 to identify potential sources of cyanide. Temporary monitoring wells were installed in 1996 between the main embankment of the impoundment and the reclaim basins. Cyanide was not detected in groundwater from the temporary wells, indicating that the impoundment was not the source. Inspection of the east basin liner indicated that the source of leakage was likely the east reclaim pond.

The portion of the east reclaim basin where the tailings impoundment underdrains enter the basin was dewatered and inspected in 1995. Defects in the liner were detected and initial repairs were made at that time. The repair work continued in 1996 by reconstructing the double-liner system of the east basin to minimize the potential for leakage. A third liner was added to the sump area of the east basin. Groundwater wells around the basin area are monitored monthly by GSM (GSM 1998a). An insufficient time has elapsed since the repairs were made to detect (based on monitoring well data) whether or not the repairs to the east reclaim pond liner have been effective in eliminating leakage.

Historic Groundwater Quality

Ambient groundwater quality in the vicinity of the tailings impoundments is provided in the database at GSM and in the records provided to the Montana DEQ (GSM 1995a, 1995c, 1996a). Appendix B contains summary tables of the water quality data, and statistical relationships for various groundwater regions that have been delineated for the site for purposes of impact analyses. In general, ambient water quality is good in the areas east and south of Tailings Impoundment No. 2, with statistical mean TDS values of about 400 to 600 mg/L and sulfate levels less than 100 to 300 mg/L. Downgradient of Tailings Impoundment No. 1 in the areas of the south pumpback wells and west of the impoundment, water quality is poorer with TDS mean values on the order of 1,000 to 1,200 mg/L, and sulfate concentration means of about 350 to 400 mg/L. In general, pH is near neutral, and metals concentrations are below Montana Numeric Water Quality Standards in the groundwater around the tailings impoundments.

Evaluation of Historic Seepage Impacts to Current Groundwater Quality

The seepage that migrated past the slurry wall below Tailings Impoundment No. 1 prior to 1990 traveled preferentially to the south within the shallow alluvium and then through gravels associated with the Jefferson River hydrologic system. Cyanide was detected at very low concentrations in groundwater off-site of the Golden Sunlight Mine property in May 1985 from a private well located approximately 1.3 miles southeast of the slurry wall.

In response to detection of contaminants, GSM monitored over 20 private wells in the vicinity of the mine site. Seven of the wells showed the presence of cyanide at least once during the monitoring period. GSM subsequently installed water treatment systems for potentially affected well owners and has monitored 13 residential wells on a regular basis for the past 10 years. Data collected from private wells since the mid-1980s show that concentrations of cyanide have been steadily diminishing with time. As of mid-1994, concentrations of total cyanide were only sporadically detected in any of the private wells off-site.

Several private wells downgradient of the tailings impoundments were found to contain elevated levels of nitrate. In 1987, an investigation by the Montana Department of State Lands (DSL 1987) concluded that the elevated nitrate levels in the wells were not related to mining activities. Subsequent to the 1987 MDSL report, an additional investigation (DSL 1988) was conducted to identify the nitrate source. The report (DSL 1988) concluded that the elevated nitrate levels were the result of natural nitrification of both existing soil organic matter and pre-existing nitrogen coupled with fallow farming and irrigation practices.

The existing impacts to groundwater as the result of historic seepage from Tailings Impoundment No. 1 were evaluated based on previous reports and available data. The groundwater impacts of concern are associated with increased concentrations of constituents common to the tailings water that seeps from the impoundment, specifically cyanide and nitrate. Maximum concentrations of cyanide and nitrate (as N) in the third row of SPB wells were reported in 1996 as being 30 mg/L and 10 mg/L, respectively (Hydrometrics 1997).

Impacts to groundwater that are associated with historic tailings impoundment seepage that was not captured by the pumpback system were evaluated by three approaches:

- constituent correlations
- isotopic data, and
- mass balance calculations

Increased concentrations of cyanide and nitrate in groundwater apparently occurred in the monitoring area during discrete periods as a result of seepage from the tailings impoundment. However, impacts to groundwater downgradient of the pumpback wells after 1990 have been greatly reduced or eliminated. Although nitrate concentrations have been mostly variable during the monitoring period, cyanide concentrations after 1990 were very low or below detection (less than 0.005 mg/L) in most monitoring wells.

Figure III-13 shows the cyanide and nitrate concentrations in monitoring well OW-4. This plot is representative of the concentration trends in downgradient monitoring wells.

The current extent of tailings impoundment seepage still shows variable cyanide concentrations in the tailings impoundment pumpback wells. Some wells have remained relatively unchanged since monitoring began over 10 years ago, and others show either increasing or decreasing concentration trends. Concentrations of seepage in groundwater have been decreasing with time in the first row of SPB wells located upgradient of the slurry cutoff wall. This trend is consistent with the gradual decrease in cyanide concentrations from the impoundment. However, cyanide concentrations in groundwater from several wells along the second and third rows of SPB wells have been gradually increasing with time. The increase is assumed to reflect gradual movement of cyanide away from the slurry wall, as induced by continued pumping from second and third row SPB wells.

Since nitrate concentrations in groundwater could be influenced by other sources (i.e., farming and irrigation practices), cyanide is a more reliable indicator of impacts from Tailings Impoundment No. 1. Although cyanide can be broken down into other constituents through a series of oxidation reactions, the reactions are generally facilitated in natural systems by high dissolved oxygen concentrations, microbial growth, or sunlight. These influences are typically not found, or are greatly reduced, in most saturated aquifer systems. Therefore, fluctuations in nitrate concentrations resulting from tailings impoundment seepage should display a correlation to relative fluctuations in cyanide concentrations, even in off-site monitoring wells. These correlations with the fluctuating nitrate concentrations have generally not been observed.

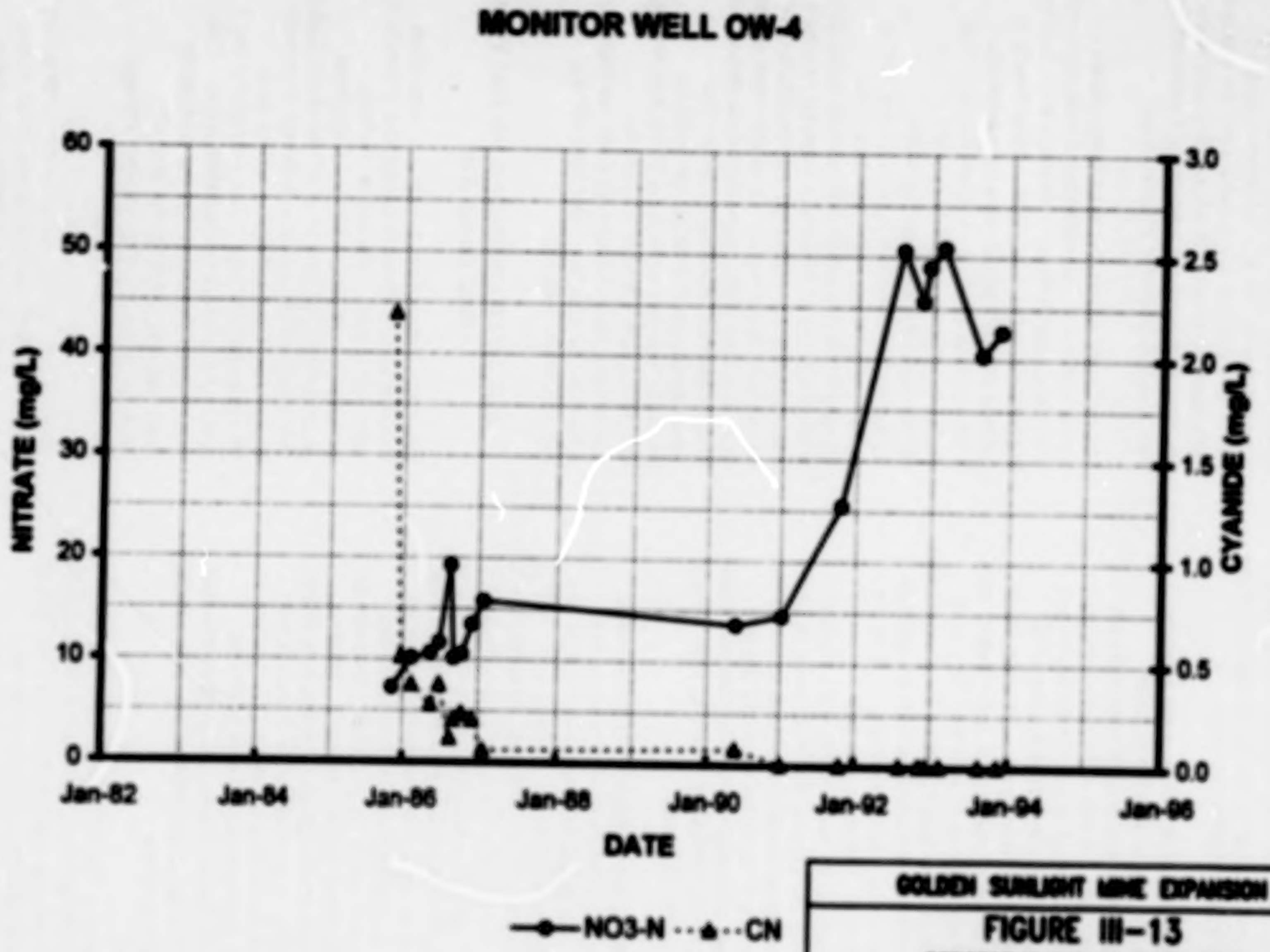
In addition, a few nitrogen isotope analyses were performed and reported by MDSL (1988). The ^{15}N isotope value measured in the Tailings Impoundment No. 1 was found to be significantly different from isotope values measured in downgradient monitoring wells. The measured isotope values, the range of typical isotope values for agricultural soils, and other studies of ^{15}N by Kreitler and Jones (1975) suggest that agricultural soils are a more likely nitrogen source for nitrate in groundwater downgradient from the tailings impoundment than seepage from the impoundment.

As previously stated, the fluctuating nitrate concentrations in downgradient monitoring wells is not likely attributable to seepage from Tailings Impoundment No. 1 because similar trends in cyanide concentrations were not observed. Further, mass balance calculations show that oxidation of the nitrogen in cyanide to form nitrate could not produce the nitrate concentrations measured in most monitoring wells. Calculations were performed that assumed 100 percent of the cyanide measured in the third row of SPB wells oxidized to nitrate and migrated downgradient with no dilution or dispersion. Resulting nitrate values were similar to or less than nitrate concentrations measured in downgradient monitoring wells. The assumptions used in these calculations, however, are very unlikely to occur and results simply support the view that nitrate concentrations in monitoring wells are highly influenced by sources other than tailings impoundment seepage.

III.B.2.g Groundwater in the East Waste Rock Dump Area

The main hydrogeologic unit in Sheep Rock Creek is recent alluvium comprised primarily of sand and gravel. This unit is relatively permeable and likely transports localized groundwater that occurs at Sheep Rock Spring. The extent of saturation is believed to be very limited and localized to the spring area. Unsaturated flow may occur throughout the draw as a result of precipitation runon. This water would then recharge the underlying Bozeman unit, which is the primary hydrogeologic unit that conveys regional groundwater in this area.

Sheep Rock Spring occurs within Sheep Rock Creek, north of the East Waste Rock Dump area. As discussed previously, the spring



SOURCE: HYDROMETRICS 1997

GOLDEN SUNLIGHT MINE EXPANSION

FIGURE III-13

REPRESENTATIVE NITRATE AND CYANIDE CONCENTRATION TRENDS

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originates from a bedrock outcrop, and a portion of the spring is captured by a catchment structure constructed by a local rancher for livestock watering. Uncaptured spring water generally flows a short distance down the draw before infiltrating into the ground.

The Bozeman unit conveys most, if not all of the groundwater beneath the existing and proposed East Waste Rock Dump area. This unit is believed to be recharged primarily from the bedrock unit and the overlying colluvial/alluvial unit along the east flank of Bull Mountain. Additional but lesser sources of recharge to the Bozeman unit include infiltration of precipitation falling directly over the area and runoff in ephemeral stream channels.

The general direction of regional groundwater flow in the Bozeman unit is to the southeast in this area. The depth to groundwater is variable, typically ranging between 100 and 200 feet below land surface.

The water quality of the Bozeman unit in this area is a mixed type with calcium, magnesium, and sodium as major cations and bicarbonate and sulfate as major anions. The pH of this water is generally neutral to slightly alkaline, and metals are at or below detectable concentrations. Nitrate values are generally in the 1.0 to 2.0 mg/L range and may reflect past agricultural use of the area.

III.B.2.h Groundwater in the West Waste Rock Dump Area

The hydrogeology of the West Waste Rock Dump area is characterized from GSM monitoring wells along the west and southern flanks of Bull Mountain. Stratigraphic data from monitoring wells PW-15, PW-16, and PW-2 indicate approximately 30 feet of alluvial and/or colluvial sands and gravels overlying the bedrock unit. The shallow sand and gravel does not appear to contain groundwater except in areas of springs and seeps. Stratigraphy for wells PW-13, PW-14, PW-17, and PW-21 consists solely of the bedrock unit. The Bozeman unit is absent in the area encompassing the West Waste Rock Dump area.

The west side PW wells are screened in and intercept groundwater from a sequence of grey and black shales, siltstones and sandstones. Wells PW-13 and PW-14 penetrate primarily light grey and buff colored siltstones and sandstones with trace amounts of pyrite. Wells PW-15, PW-16, PW-2, PW-17, and PW-21 penetrate primarily black, carbonaceous siltstones with an abundance of disseminated pyrite. The presence of sulfide mineralization is believed to influence groundwater quality.

Monitoring well logs for the West Waste Rock Dump area do not show any correlation between the occurrence of groundwater and a specific lithology. As in the pit area groundwater flow in the West Waste Rock Dump area is fractured controlled and heavily influenced by surface topography. Static groundwater levels in the West Waste Rock Dump area wells range from approximately 20 feet below land surface at well PW-17 to 365 feet below land surface at well PW-21. The PW-13 (shallow) and PW-14 (deep) well pair have depths to water of approximately 25 and 90 feet respectively. These data indicate a downward hydraulic gradient at this location. The direction of groundwater flow in this area is predominantly to the south and west.

III.B.2.i Groundwater in the Conrow Creek Area

In early 1996, GSM constructed a monitoring well (PW-45) on GSM land along the drainage divide between Sheep Rock Creek and the southernmost tributary of Conrow Creek (where the Sheep Rock diversion would be routed). The well was constructed to characterize hydrogeologic conditions and groundwater quality in the general area of the Sheep Rock diversion and Conrow Creek drainage. The well was completed to a depth of 594 feet below the land surface in siltstone and sandstone of the Paleozoic Dry Creek Formation. The static groundwater level in the well is approximately 390 feet below the land surface.

A chemical analysis of a sample from the well shows the groundwater quality is of a calcium bicarbonate type with slightly alkaline pH. The concentrations of trace metals are very low (less than 1 ppm) with many of the trace metals below detection.

GSM also established surface water monitoring sites on all three ephemeral tributaries of Conrow Creek in mid 1995. Each site was monitored on at least nine separate occasions from April 1995 through May 1996. Flow was never directly observed in the southernmost tributary (where the Sheep Rock diversion would be routed) but a runoff sample was collected using remote samplers consisting of plastic bottles buried within the ephemeral stream channel bed. Following storm events, ephemeral stream flow was directly observed four times in the northernmost tributary and three times in the middle tributary. The observed discharge varied from approximately 0.1 cfs to an estimated high of between 4 and 5 cfs.

The chemical analyses of the samples of surface flow from each of the tributaries were similar. The runoff from Conrow Creek is of a calcium bicarbonate type with alkaline pH between 7.3 and 8.5. In general, trace metal concentrations are very low, with the exception of naturally elevated total aluminum and total iron, which are over several ppm.

III.B.3 Water Rights and Use

GSM owns all water rights within the mine area.

III.C SOILS AND RECLAMATION

Since 1988, three site-specific soil surveys have been completed within permitted or proposed project area boundaries of the Golden Sunlight Mine. The first survey was completed in 1988 by Multitech Services Division of MSE, Inc. (Ottersberg 1988) and encompassed approximately 1,070 acres to be disturbed by the then proposed North and West Waste Rock Dumps, as well as the proposed tailings facility. The primary objective of this survey was to identify soil materials that could be used for resoiling and revegetating project disturbances. To date, the majority of the area included in this survey has been disturbed by project facilities, and a portion of the disturbed soils are currently located in soil stockpiles or have been respread over selected disturbed project components, which are in various stages of reclamation.

The second detailed survey was completed during 1993 and 1994 by WESTECH (Houlton and Noel 1994) and covered approximately 3,200 acres surrounding mine project disturbances existing at the time of the survey. The primary objectives of this survey were to identify soil materials suitable for salvage and for use as capping material for the tailings facility. Two sets of potential soil salvage depths were presented, based on commonly accepted physio-chemical criteria, as well as a calculation based on organic matter content by horizon. In 1995, a supplemental survey was conducted by WESTECH (Houlton and Noel 1995) on approximately 800 acres near the extreme northeastern portion of the proposed project area boundary. Soil mapping information and data collected during both the WESTECH surveys are included in the 1995 Houlton and Noel report. In addition, soil map unit boundaries delineated by Ottersberg also are presented on the map included in this report, although soil map unit and pedon information have not been incorporated into the document.

The following sections summarize the soil data presented in the reports cited above. The summaries and Table III-2 (based on data presented in Houlton and Noel 1995) emphasize soil characteristics important with respect to soil material quality, salvageability, and revegetation success potential. Ranges presented in Table III-2 reflect characteristics for the dominant soils present. For ease of presentation, the summary is divided into four sections representing definitive portions of the proposed project area.

III.C.1 Western Portion of Project Area

Soils located along the western border of the project area would be affected by expansion of the West Waste Rock Dump and possibly the pit facility. Soil parent materials include a variety of intrusive rocks, shale, colluvium, and alluvium. Soils forming on ridges occur on slopes ranging from nearly level to over 50 percent and are typically less than 10 inches deep to bedrock, although deeper ridge-top soils do occur. Soil textures throughout the profiles range from gravelly loams to extremely gravelly or cobbly loams. Soils of moderate slopes and swales are greater than 60 inches to bedrock with slopes typically ranging from 0 to 33 percent. Surface soil textures are loams and clay loams while subsurface textures are very cobbly or very gravelly silt and sandy loams. Soils overlying steep and very steep slopes typically occur on angles exceeding 33 percent though lesser slope angles can occur under highly variable topographic conditions. The majority of these soils are greater than 60 inches deep to bedrock, with shallower depths more prevalent along the northwestern border of the project area. Surface soil textures range from sandy loams to clay loams, while subsurface textures range from very cobbly sandy loams to very cobbly silt loams.

Soil coarse fragment contents (gravel-, cobble-, and rock-sized geologic materials) are typically somewhat higher in the western as compared to the eastern and southern portions of the project area and are generally comparable to the northwestern portion (see Table III-2). Coarse fragment content has a dual effect on the quality of soils for revegetation purposes. The higher the coarse fragment content (assuming the fragments do not readily weather to soil) the less the available water holding capacity of the

Table III-2

Typical Range of Soil Characteristics

Topographic Position	Coarse Fragment Content (% volume)		pH		Electrical Conductivity (mmhos/cm)		[illegible]	
	Surface Soils	Subsurface Soils	Surface Soils	Subsurface Soils	Surface Soils	Subsurface Soils	[illegible]	[illegible]
Western Portion of the Project Area:								
Ridges	15-22%	0-60%	5.8-6.2	NA	<1.0	NA	3-6 in.	0-3 in.
Slopes/swales	0-21%	14-60%	5.7-7.0	6.1-7.8	<1.0	< 1.0	10-24 in.	0 in.
Steep slopes	9-60%	56-60%	5.7-7.0	6.5	<1.0	<1.0	5-24 in.	0 in.
Steep Slopes to 75+%	No data-soils not proposed for salvage due to slope steepness							
Eastern Portion of the Project Area:								
Pediments	5-15%	20-60%	6.4-7.8	7.5-8.2	<1.0-3.4	<1.0-7.8	16-27 in.	0-27 in.
Pediment/Basin	15-25%	25-30%	7.3-7.8	7.3-7.8	<1.0	<1.0	>77 in.	33 in.
Sideslopes	3-22%	0-64%	6.4-7.8	6.7-8.1	<1.0	<1.0-6.3	22->60 in.	12-22 in.
Terrace/Fan	5-15%	5-43%	NA	NA	NA	NA	25 in.	NA
Channels	12%	77%	4.5-7.8	4.5-7.9	<1.0-3.1	<1.0-3.1	3 in.	0 in.
Northeast Portion of the Project Area:								
Sideslopes	20-47%	30-73%	7.4	8.0	<1.0	<1.0	0-60 in.	0-30 in.
Terraces	5-52%	5-60%	7.7	7.0-7.7	<1.0	5.4-8.7	20-65 in.	0-27 in.
Pediments	0-30%	0-60%	6.9-7.8	7.4-8.4	<1.0	<1.0-6.3	60-120 in.	13-22 in.
Alluvial fans	<5-40%	<5-50%	7.1-8.1	7.7-8.2	<1.0	<1.0-1.5	11-60 in.	17-40 in.

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Table III-2 (Continued)

Topographic Position	Coarse Fragment Content (% volume)		pH		Electrical Conductivity (mmhos/cm)		Salvage Depths (inches)	
	Surface Soils	Subsurface Soils	Surface Soils	Subsurface Soils	Surface Soils	Subsurface Soils	[illegible]	[illegible]
Southern Portion of the Project Area:								
Sideslopes	0-25%	0-30%	7.0-7.8	7.6-8.8	<1.0	<1.0-6.4	8->120 in.	0-22 in.
Steep Slopes	<5-25%	0-30%	7.0-7.7	7.7-8.8	<1.0	<1.0-1.5	0-52 in.	0-46 in.
Pediments	5-15%	0-40%	6.8-7.7	7.3-7.8	<1.0	<1.0-7.4	11->85 in.	10-20 in.
Ridgetops	20%	15-70%	7.5-7.9	8.0	<1.0	<1.0	15 in.	27 in.
Slopes/fans	<5-10%	10-70%	6.8-7.7	7.4-8.0	<1.0	<1.0-6.9	52-60 in.	17-48 in.

NA - Data not available or information not present in report.

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soil for any given soil texture, by volume. For example, a loam soil containing no coarse fragments can store approximately 2.0 inches of water per foot of soil material. A loam soil containing 20 percent coarse fragments can store approximately 1.6 inches of water, while a loam soil containing 50 percent coarse fragments is capable of storing 1.1 inch of water. Conversely, coarse fragments occurring on the soil surface decrease the susceptibility of soil to erosion by providing an "armoring affect". The calcium carbonate content of the dominant soils of this area, as reported in Houlton and Noel (1995), are comparatively low and indicate a low pH buffering capacity. Expressed as "neutralization potential" (and reported as tons of $CaCO_3$ per 1,000 tons of soil), values reported for horizons of selected dominant western soils range from less than 1.0 ton to a maximum of 17.1 tons with the majority of values typically below 1.0 ton. These values are notably lower than those of soils of other portions of the project area. The surfaces of soils in this area are typically overlain with a moderate to high percentage of coarse rock fragments.

Soils of the western portion of the project area have inherent erodibilities generally comparable to soils of the eastern and southern portions as expressed by soil profile K-factors. There are only minor differences in K-factors among soils of differing topographic positions. Plant roots are concentrated in the upper 24 inches of the soil profile where such information was reported for the dominant soils of this portion of the project area.

III.C.2 Eastern Portion of Project Area

Soils to the east of the existing East Waste Rock Dump Complex are being impacted by supplemental dumping activities. Rock outcrops are common in the northern portion of this area reflecting limestone, slate, and volcanic bedrock types. Soil salvage is not considered feasible over these map units due to slope steepness, shallow soil depths, surficial stoniness, and/or the presence of surface rock exposures. Soils overlying pediment surfaces occur on slopes ranging from nearly level to 33 percent and are over 90 inches deep to bedrock. Surface soil textures are loams and silt loams, while subsurface textures vary from gravelly sandy loams to very gravelly loams. Soils common to pediment and basin complexes are greater than 60 inches deep and overlie slopes from 8 to 33 percent. Gravelly loams and clays typify surface textures, while gravelly to very gravelly loams are common subsurface soil textures. Sideslope soils are quite varied with slopes ranging from nearly level to over 50 percent. Soil depths are typically greater than 60 inches, although sideslope soils developing in limestone may be less than 6 inches to bedrock. As with slope, textures are highly variable ranging from loams to cobbly silt loams and extremely gravelly loamy sands to gravelly sandy clay loams throughout the profile. Soils of terrace/fan complexes and ephemeral stream channels are greater than 60 inches deep to bedrock and typically occur on slopes less than 8 percent. Textures vary from clay loams to very gravelly loamy sands surficially and from loams to extremely gravelly sands in deeper horizons.

Coarse fragment content of the surface layers of these soils are typically lower than the western and northeastern portions of the project area and somewhat higher than the soils of the southern part of the project site. Coarse fragment contents of the subsurface horizons are comparatively high and similar to the contents of the western and northeastern portions of the project area. Neutralization potentials for these soils ranges from less than 1 ton to 308 tons of $CaCO_3$ per 1,000 tons of soil by horizon with values in excess of 100 tons being common. These soils exhibit a comparatively high buffering capacity.

In terms of inherent erodibility, soils of the eastern portion of the project area are comparable to soils of the western and southern portions but slightly less erodible than soils of the northeast portion. Few differences exist between K-factors of soils overlying varying topographic positions. In this portion of the project area, plant roots are concentrated in the upper 14 to 40 inches of the soil profiles of the dominant soils types.

With respect to overall soil characteristics and soil salvage potentials, the soils of this portion of the project area typically overlie less steep slopes, are deeper, have lower rock (coarse fragment) contents, and have higher pH values than the soils of the western portion of the project area. These soils have, in part, developed in limestone as well as calcareous loess and have a net buffering capacity due to a relatively high calcium carbonate content. Soil volumes identified in this, as well as the remainder of the eastern portion of the project area, would meet the agencies' resoiling depth requirements of 48 inches (24 inches of soil cover plus 24 inches of oxidized cap rock) required to be placed over acid-producing mine waste. In addition, lower slope angles of the proposed East Waste Rock Dump area provide an opportunity to salvage soils in two lifts, using scrapers, thereby increasing soil salvage efficiencies.

III.C.3 Northeast Portion of Project Area

Included as a potential buffer zone for the proposed East Waste Rock Dump Complex, this area could be disturbed by waste rock dump activities and associated mine facilities in the future. Rock outcrops consisting of limestones, slates, quartzites, sandstones, and various volcanic rocks are prevalent throughout this portion of the proposed project area on slopes ranging from 8 to over 50 percent. Any soil overlying these outcrops is not considered to be salvageable due to shallow depth, the presence of surface rock features, and/or slope constraints. Soils overlying sideslopes adjacent to limestone rock outcrops occur on slopes up to 50 percent and range from less than 6 to over 60 inches in depth. Surface soil textures range from silt loams to cobbly silt loams, and subsurface textures range from gravelly to extremely gravelly loams. Terrace soils are over 60 inches deep and occur on slopes less than 33 percent. These soils have surface and subsurface textures ranging from very gravelly loamy sands to sandy loams and gravelly sands to silt loams, respectively. Soils of pediment surfaces occur over a variety of slopes and are typically over 60 inches deep. Surface textures are gravelly loams and silt loams, while subsurface textures range from extremely gravelly sandy loams to clay loams. Alluvial fan soils are typically greater than 60 inches deep overlying slopes ranging from 0 to over 50 percent. Surface soil textures range from loams to clay loams, and subsurface textures range from extremely gravelly loamy sands to gravelly sandy clay loams.

Coarse fragment contents of the soils of this portion of the project area are comparatively high and generally parallel those of the west. Neutralization potential of the dominant northeastern soils are comparatively high and are similar to those of the eastern portion of the project area.

Soils are slightly more erodible, inherently, than those of the western, eastern, and southern portions of the project area. Soils of pediment surfaces have somewhat higher soils K-factors and are therefore somewhat more erodible than soils of terrace, alluvial fan, sideslope, and drainage topographic positions. Plant roots are typically concentrated in the upper 40 inches of the dominant soil profiles.

In line with the comparison of soils overlying the eastern versus western portions of the project area, these soils typically occur on less steep slopes, are deeper, exhibit lower rock contents, and have higher pH and buffering capacities. Soil volumes available for salvage would meet the agencies' 48-inch replacement depth requirement goals for this project.

III.C.4 Southern Portion of Project Area

Soil parent materials in the tailings pond disturbances and borrow area developments include volcanic rocks, claystones, and sandstones in steeper topographies, and alluvium and loess on more gently sloping sites. Soils overlying sideslopes occur on slopes up to 33 percent and depths to bedrock typically exceed 60 inches. Sandy loams to cobbly sandy clay loams typify the range of surface soil textures, while subsurface textures range from sandy loams to clays. Steeper slopes, up to and exceeding 50 percent, are overlain with soils from 0 to over 60 inches deep. Surface soil textures range from silt loams to cobbly sandy clay loams. Subsurface textures range from sandy loams and clays to gravelly sands. Pediments are overlain with soils from 35 inches to greater than 60 inches to bedrock on highly variable slope angles. Sandy loams, loams, and gravelly loams are typical of textures throughout the profiles of these soils. Ridgetop soils are greater than 60 inches deep to bedrock and occur on slope angles less than 30 percent. Surface soil textures are gravelly sandy loams, and subsurface textures range from very gravelly to very cobbly sands. Midslopes and alluvial fans are overlain with soils 48 inches to greater than 60 inches deep to bedrock on slopes ranging from nearly level to over 50 percent. Silt loam, loam, and sandy loam textures dominate the profiles of these soils.

The coarse fragment contents of the soils of the southern portion of the project area are typically the lowest of any portion of the project area in terms of both the surface and subsurface horizons. The neutralization potential of the these soils is variable, ranging from less than 1.0 to a high of 484 tons of $CaCO_3$ per 1,000 tons of soil, by soil horizon. Overall, however, these soils exhibit a comparatively high pH buffering capacity with moderate to high neutralization potentials.

Soils of this area have slightly lower inherent erodibility characteristics as compared to soils overlying the remainder of the project area. Soils of sideslopes, to a certain degree, are less erodible due to rock fragment contents than soils of other topographic positions. Plant roots are typically concentrated in the upper 24 to 40 inches of the soil profiles representing the dominant soils of this area.

As compared to soils overlying the western portion of the project area, soil volumes available for salvage in the south would meet the agencies' 48-inch replacement depth requirement goal as noted above. These soils exhibit lower rock contents, have higher pH and buffering capacities, are deeper, and overlie less steep slopes than the soils of the western portion of the project area. The lower slope angles dominant in this area permit the opportunity to salvage soils in two lifts with scrapers.

Five soil map units were evaluated for use as tailings capping material to depths ranging from 16 to 180 inches depending upon soil type. Loamy soil textures predominate, with coarse rock fragment contents variable and increasing with depth where fragments are present. Electrical conductivities (expressed in mmhos/cm) of the potential capping material range from 0.3 to 8.8 mmhos/cm. The pH values range from 6.7 to 8.5. Neutralization potentials of these soils typically range from 7 to 341 tons of $CaCO_3$ per 1,000 tons of material.

III.D VEGETATION AND WETLANDS

III.D.1 Vegetation

According to Kuchler (1975), the project area is located in the grama-needlegrass-wheatgrass grassland and Douglas fir forest. Site-specific vegetation surveys were conducted in the project area in 1988 and 1995 (Scow 1995). Specific information that was obtained from these surveys included estimates of canopy cover, shrub and tree densities, annual forage production, range condition, species diversity and abundance, and noxious weed infestations in the project area. Annual forage production was estimated for grassland and shrubland communities but was not estimated for savannah or forested communities. A total of six vegetation types occur in the proposed disturbance boundary: grassland, savannah, pastureland, mixed shrub/grassland, coniferous forest, and wetlands. The first five vegetation types are discussed below. Wetlands are discussed in the following section. The distribution of these types is based on subtle changes in soil texture, available water, and topographic position.

Grassland is the most prevalent vegetation type present within the proposed disturbance area. Plant communities associated with this type include the needleandthread/blue grama and bluebunch wheatgrass/blue grama communities. This type is characterized by a sparse shrub component and a dominant herbaceous layer consisting of various forbs and graminoids (i.e., grasses and grass-like plants). Common forbs include plains prickly pear, club moss, and scarlet globemallow and dominant graminoids include needleandthread, blue grama, threadleaf sedge, western wheatgrass, and bluebunch wheatgrass. Species diversity within this vegetation type ranges from 63 to 76 species (average - 70 species). The needleandthread/ blue grama community supports 76 species, which include 17 graminoid (i.e., grasses and grass-like plants), 55 forb, and 4 shrub species. The bluebunch wheatgrass/blue grama community supports 63 species, which include 13 graminoid, 44 forb, 5 shrub, and 1 tree species.

The average canopy cover for the grassland vegetation type is approximately 70 percent, of which 63 percent is contributed by forbs and graminoids and 7 percent is contributed by shrubs. Graminoids contribute approximately 53 percent cover within this vegetation type; primary cover species include needleandthread (23 percent), blue grama (16 percent), threadleaf sedge (9 percent), and western wheatgrass (4 percent). Forbs contribute approximately 10 percent cover within this vegetation type; primary cover species include plains prickly pear (2 percent) and club moss (3 percent). Annual forage production for the needleandthread/blue grama and bluebunch wheatgrass/blue grama communities were 1,043 and 735 pounds per acre, respectively; average annual forage production for this vegetation type is approximately 880 pounds per acre.

Plant communities associated with the savannah vegetation type include Rocky Mountain juniper/western wheatgrass, Rocky Mountain juniper/bluebunch wheatgrass, and limber pine/bluebunch wheatgrass. The savannah type is characterized by a co-dominant overstory of Rocky Mountain juniper and limber pine and an understory consisting of a variety of forbs and grasses. Prevalent shrubs include Wyoming big sagebrush, broom snakeweed, fringed sage, skunkbush sumac, and curlleaf mountain mahogany. Dominant forbs present in this type include Loesel tumblemustard, tumblemustard, stiff-leaf penstemon, and tufted fleabane. Common graminoids include western wheatgrass, blue grama, bearded wheatgrass, bluebunch wheatgrass, needleandthread, and threadleaf sedge. Species diversity within this vegetation type ranges from 35 to 92 species (average - 64 species). The Rocky Mountain juniper/bluebunch wheatgrass community supports the fewest number of species (35 plants), while the limber pine/bluebunch wheatgrass community supports the greatest number of species (92 plants).

The average canopy cover for the savannah vegetation type is approximately 66 percent. Average foliar cover for trees and shrubs is approximately 45 percent, of which the majority is contributed by Rocky Mountain juniper

(33 percent) and limber pine (9 percent). Forbs and graminoids collectively contribute an average of 21 percent foliar cover. The average densities of trees greater than 1-inch diameter at breast height (dbh) includes 274 Rocky Mountain juniper and 63 limber pine per acre, respectively. The average density of shrubs is 701 plants per acre which includes curlleaf mountain mahogany (321 plants per acre), big sagebrush (204 plants per acre), and skunkbush sumac (176 plants per acre).

Pastureland predominantly consists of crested wheatgrass and annual and biennial weedy species. This vegetation type occurs in areas disturbed by historic ranching activities. Crested wheatgrass was used to develop early spring pasture in these disturbed areas and weedy species naturally invaded and became established. Dominant forbs and grasses include tumblemustard, yellow sweetclover, tansymustard, annual sunflower, lanweed, and crested wheatgrass. Average foliar cover is approximately 82 percent, of which 43 percent is associated with crested wheatgrass and 39 percent is associated with weedy species. Approximately 33 percent of foliar cover is contributed by tumblemustard (21 percent) and yellow sweet clover (13 percent). Estimated annual production for pastureland is approximately 4,145 pounds per acre. This vegetation type supports 27 species, which include 4 graminoid, 22 forb, and 1 shrub species.

The mixed shrub/grassland type includes the Wyoming big sagebrush/western wheatgrass, Wyoming big sagebrush/bluebunch wheatgrass, black sagebrush/bluebunch wheatgrass, and curlleaf mountain mahogany/bluebunch wheatgrass communities. The mixed shrub/grassland type is characterized by a dominant overstory consisting of various shrubs, forbs, and graminoids. Common shrubs include Wyoming big sagebrush, fringed sage, black sagebrush, curlleaf mountain mahogany, broom snakeweed, and skunkbush sumac. Dominant forbs that are present in this type include club moss, American vetch, silky lupine, Hood's phlox, thrifty goldenweed, and Drummond's pennyroyal. Western wheatgrass, bluebunch wheatgrass, needleandthread, blue grama, Indian ricegrass, and threadleaf sedge are the prevalent graminoids associated with this type. Species diversity within this vegetation type ranges from 47 to 99 species (average - 73 species). The black sagebrush/bluebunch wheatgrass community supports the lowest number of species (47 plants), while the Wyoming big sagebrush/bluebunch wheatgrass community supports the greatest number of species (99 plants).

The average canopy cover for the mixed shrub/grassland type is approximately 77 percent. Average foliar cover for shrubs is approximately 30 percent, of which the majority is contributed by Wyoming big sagebrush (13 percent), black sagebrush (9 percent), and curlleaf mountain mahogany (8 percent). Forbs and graminoids collectively contribute an average of 46 percent foliar cover. The average density of shrubs is 6,646 plants per acre, which includes black sagebrush (3,325 plants per acre), Wyoming big sagebrush (2,386 plants per acre), and curlleaf mountain mahogany (935 plants per acre). Annual forage production for the Wyoming big sagebrush/western wheatgrass and Wyoming big sagebrush/bluebunch wheatgrass communities were estimated to be 1,174 and 1,125 pounds per acre, respectively. Estimated annual forage production for the black sagebrush/bluebunch wheatgrass community was 1,035 pounds per acre. Average annual forage production for this vegetation type is approximately 1,111 pounds per acre.

The coniferous forest type includes the limber pine/Rocky Mountain juniper community, which occurs along the northern and eastern aspects of incised, intermittent drainages. This vegetation type intergrades with the savannah and mixed shrub/grassland types. This community is characterized by a dominant overstory consisting of limber pine, Rocky Mountain juniper, and skunkbush sumac, and a subdominant understory consisting of various forbs and grasses. Dominant forbs and grasses include cudweed sagewort, yellow sweet clover, western wheatgrass, bluebunch wheatgrass, red threeawn, Kentucky bluegrass, alkali bluegrass, and blue grama. This vegetation type supports

52 species, which include 13 graminoid, 29 forb, 8 shrub, and 2 tree species.

The estimated canopy cover for the coniferous forest type is 70 percent. Average foliar cover for trees and shrubs is approximately 52 percent, of which the majority is contributed by limber pine (29 percent) and Rocky Mountain juniper (20 percent). Forbs and grasses collectively contribute 18 percent foliar cover. The densities of trees greater than 1-inch dbh include 150 Rocky Mountain juniper and 29 limber pine per acre, respectively. Shrub density averaged 1,280 plants per acre, comprised of skunkbush sumac (666 plants per acre), wax currant (222 plants per acre), western snowberry (222 plants per acre), and Wood's rose (167 plants per acre).

Five noxious weeds occur in the project vicinity including Canada thistle (*Cirsium arvense*), whitetop (*Cardaria draba*), spotted knapweed (*Centaurea maculosa*), leafy spurge (*Euphorbia esula*), and dalmatian toadflax (*Linaria dalmatica*); these species are included on the county noxious weed species list, which was designated under the County Weed Control Act 7-22-2101(5), MCA. These species are commonly associated with recent or historic disturbance areas (e.g., roadsides, abandoned roads, homesteads, livestock concentration areas) and intermittent drainages affected by fluvial events.

III.D.2 Wetlands and Waters of the U.S.

Wetlands and Waters of the U.S. (WUS) occurring in the project area are shown on Map III-6. A total of approximately 32.4 acres of WUS occur or have occurred in the proposed project boundary (27.0 acre of non-wetland WUS and 5.4 acres of wetland WUS). Past mining activities have resulted in the filling, excavation, or removal of 3.1 acres of non-wetland WUS and 0.08 acre of wetland WUS, leaving 29.2 acres of WUS remaining in the project boundary.

Approximately 2.5 acres of non-wetland WUS were disturbed between 1990 and 1994 under Amendment 008 operations prior to the Settlement Agreement. In addition, approximately 0.6 acre of non-wetland WUS will be filled through completion of currently permitted mining activities. Therefore, 23.9 acres of non-wetland WUS will remain following completion of the *Interim Dump Plan*.

Past disturbance to wetland WUS (0.08 acre) includes the filling or removal of four wetlands that were associated with springs; these were the Midas Spring (0.002 acre), North Borrow Springs (0.040 acre), Arkose Valley Spring (0.005 acre), and Sunlight Spring (0.012 acre). The wetlands associated with Midas Spring, North Borrow Springs, and Sunlight Spring supported a prevalence of herbaceous wetland species; vegetation present at the Arkose Valley Spring wetland was dominated by upland species, yet included hydric soil and hydrologic indicators.

Ten wetland areas (5.3 acres) remain in the project area, of which six wetlands are associated with springs. The six spring areas that support wetland vegetation include Sheep Rock Spring (0.013 acre), Rattlesnake Spring (0.008 acre), Bunkhouse Springs (0.188 acre), Steppan Spring (0.010 acre), Steppan Original Spring (0.002 acre), and Beaver Springs (0.028 acre). The other wetlands are the West Tailing wetland (0.101 acre), the Jefferson Slough Bank Fringe (4.920 acres), the Jefferson Slough Floodplain Depression (0.070 acre), and the Gravel Quarry (0.010 acre). The wetland areas that may potentially be affected by the proposed project are described below. It is unknown whether the unnamed spring west of the proposed project boundary supports wetland vegetation.

The Sheep Rock Spring wetland is located northwest of the East Waste Rock Dump Complex and covers less than 0.1 acre (0.013 acre). This wetland includes two small areas that are inundated by surface water, contain saturated soils, and support a prevalence of wetland species. The first wetland area extends from the improved spring approximately 35 feet into an ephemeral drainage and continues within the drainage for approximately 75 feet. The second wetland is limited to a small area immediately adjacent to a

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livestock watering tank. Dominant plant species that occur in these two wetland areas include redtop, bearded wheatgrass, Kentucky bluegrass, hounds tongue, Baltic rush, and heart-podded hoarycress.

The Rattlesnake Spring wetland is located southeast of the plant site and covers less than 0.1 acre (0.008 acre). Water from this spring likely originates from an adit. This wetland includes a 360-square-foot area that is inundated by surface water, contains saturated soils, and supports a prevalence of wetland species. This wetland is characterized by a prevalence of herbaceous species with a sparse tree overstory. Dominant plant species that occur in this wetland include tufted hairgrass, redtop, Rocky Mountain juniper, and limber pine.

One wetland occurs within the outer portion of the proposed disturbance area (i.e., buffer zone). This wetland (.013 acre) occurs at and below Bunkhouse Spring and supports a prevalence of wetland species including redtop, tufted hairgrass, Baltic rush, Nebraska sedge, and wideleaf cattail. Other species that occur in the wetland include Canada thistle and Kentucky bluegrass. Vegetation located immediately adjacent to the spring is dominated by wideleaf cattail and grasses; sedges are most prevalent in the swale directly below the spring.

The Steppan Spring wetland is located southeast of the existing West Waste Rock Dump Complex and covers less than 0.1 acre (0.010 acre). This wetland originates at the spring and continues along a 300-foot segment of the drainage channel located below the spring. This wetland is characterized by sparse plant cover; wetland vegetation comprises up to 58 percent of the species composition present within the wetland. Dominant plant species that occur in this wetland include redtop, slender wheatgrass, rough bentgrass, Baltic rush, and spotted knapweed.

The Steppan Original Spring wetland is located approximately 1,800 feet southwest of Steppan Spring and covers less than 0.1 acre (0.002 acre). This wetland receives water from a collapsed abandoned adit. Wideleaf cattail is the dominant wetland plant present within the wetland.

The Beaver Springs wetland is located immediately north of the northwest corner of the proposed disturbance boundary and covers less than 0.1 acre (0.028 acre). The wetland extends from a livestock watering pond, which receives water from the improved spring and culvert system, to a drainage channel located below the pond. Wetland plant species comprise up to 56 percent of the total species composition. Common plant species present within the wetland include redtop, Kentucky bluegrass, rough bentgrass, crisped starwort, common chickweed, fowl bluegrass, and common horsetail.

The West Tailing wetland (0.042 acre) occurs within an incised drainage channel located adjacent to the southwest corner of Tailings Impoundment No. 1. Water for this wetland was provided by a wildlife watering trough maintained by GSM in the upper portion of the drainage. GSM has since discontinued the water supply to this watering trough. This wetland occurs within two reaches of the drainage. The upper wetland area extends approximately 320 feet in the drainage channel and is approximately 8 feet-wide and the lower wetland area extends approximately 370 feet and is approximately 5 feet wide. The dominant wetland plant species observed in this wetland was wideleaf cattail.

III.E WILDLIFE AND FISHERIES RESOURCES

III.E.1 Wildlife Resources

III.E.1.a Wildlife Habitats

A variety of habitats utilized by resident and migratory wildlife species are found within the proposed disturbance area and general vicinity of the Golden Sunlight Mine. The available aboveground habitat can be categorized into six general vegetation types: 1) open grassland, 2) savannah, 3) pastureland, 4) mixed shrub/grassland, 5) coniferous forest, and 6) wetlands (see Section III.D, Vegetation and Wetlands). The proposed disturbance area is composed of approximately 42 percent open grassland, 30 percent savannah, 18 percent pastureland, 9 percent mixed shrub/grassland, 1 percent coniferous forest, and less than 1 percent riparian communities. This composition is similar to the surrounding habitat. Additional belowground habitat for wildlife exists in the form of abandoned mine shafts and adits created by historic mining activities.

Surface water occurs at the existing mine only in the tailings impoundments, pit pond sump, ore stockpile pond, and at seven small springs and seeps (see Section III.B, Water Resources). The toxicity of the water in the pit pond sump and tailings impoundments makes these areas unavailable as primary breeding or foraging habitat for wildlife (GSM's hazing and fencing program to prevent wildlife from accessing these areas is discussed in Section II.B.1.a, Current Mining Operations). Springs in the general vicinity of the mine site provide potential water sources for large and small mammals, breeding and foraging habitat for amphibians, and foraging habitat for bats. Seeps and springs occurring in the mine area (discussed in Section III.B.2.d, Springs and Seeps) include Sheep Rock Spring, Rattlesnake Spring, Bunkhouse Springs, Steppan Spring, Steppan Original Spring, Beaver Springs, and an unnamed spring. Because of the limited surface water available in the mine area, these springs provide an important water source for local wildlife, with the exception of Steppan Spring, which has a low natural pH.

The mine site is located in the Jefferson River watershed. No perennial stream riparian habitat is located within the proposed disturbance areas. The Jefferson River flows in a northeasterly direction, passing approximately 1.4 miles south of the mine. The south-flowing Boulder River passes approximately 1.3 miles east of the mine. Both rivers converge near Cardwell, approximately 3 miles southeast of the mine. Surface runoff from snowmelt and storm events flows towards the Jefferson River via several small intermittent streams on the western, southern, and eastern portions of the mine site.

Surface runoff generally is absorbed in the alluvial bed of intermittent streams before reaching the Jefferson River. The increased moisture concentrations along these intermittent streams have created quasi-riparian communities that contain sparse stands of narrowleaf cottonwood mixed with limber pine and rocky mountain juniper. These quasi-riparian communities provide more structural diversity than the surrounding landscape, providing habitat for a variety of mammal and bird species. The western portion of the disturbance boundary extends into several small, unnamed intermittent stream drainages that flow generally southwest into St. Paul Gulch. Runoff from the southern portion of the permit boundary flows directly south towards the Jefferson Slough. The eastern portion of the disturbance boundary extends into several small unnamed intermittent streams that flow generally southeast from Sheep Rock to form Sheep Rock Creek.

III.E.1.b Large Mammals

The mule deer is the most common big game species in and around the existing mine site. Over 50 mule deer have been observed within the existing mine permit boundary on a single occasion. The highest level of mule deer use appears to occur in late autumn, with lesser numbers of mule deer remaining within the existing permit boundary and immediate vicinity throughout the winter and remainder of the year. Observational data appear to indicate that after hunting season ends, many of the mule deer using the area move north to winter along the east slopes of Bull Mountain or in the vicinity of Black Butte located northwest of the permit area (GSM 1995b, Volume 2, Appendix 3.4-1). No designated critical winter range for mule deer has been identified for the Proposed Action, but important winter range exists for mule deer on south-facing slopes in shrub/grassland areas within the proposed disturbance boundary (see Section III.D, Vegetation and Wetlands; Rau 1988). The juniper-mountain mahogany and big sagebrush components of the shrub/grassland community type receive extensive winter use by mule deer (MDSL and BLM 1980; Rau 1988).

Pronghorn are common in open grassland habitat within and east of the proposed disturbance boundary, especially during winter (GSM 1995b, Volume 2, Appendix 3.4-1). No designated critical winter range for pronghorn exists within the proposed disturbance boundary, but Trout (1988) noted that pronghorn utilize habitats near the mine as winter range and suggested that critical winter range for antelope exists outside the proposed disturbance boundary west of the mine. Pronghorn appear to use the area in the vicinity of the mine throughout the year (Rau 1988; GSM 1995b, Volume 2, Appendix 3.4-1). Single does observed in May and June may indicate that a few pronghorn fawn in the vicinity of the mine (GSM 1995b, Volume 2, Appendix 3.4-1).

White-tailed deer have been observed on at least one occasion within the existing mine permit boundary and adjacent habitats (GSM 1995b, Volume 2, Appendix 3.4-1). White-tailed deer are more common in the dense riparian woodland habitats along the Jefferson and Boulder Rivers south and east of the mine site (Trout 1988). Suitable riparian woodland habitat for this species does not occur within the proposed disturbance boundary.

Elk use the habitats immediately north of the permit boundary, as evidenced by fresh tracks and droppings (GSM 1995b, Volume 2, Appendix 3.4-1). Aerial surveys and hunting records have identified small herds of elk on the southeastern slopes of Bull Mountain, approximately 2 to 4 miles north of the permit boundary (MDSL and BLM 1980; GSM 1995b, Volume 2, Appendix 3.4-1). Additional sightings of small groups have been recorded within several miles of the northern boundary of the mine site (GSM 1995b, Volume 2, Appendix 3.4-1).

Black bear, moose, and mountain lion are present in areas surrounding the mine and may occasionally wander through areas within the existing mine permit boundary. No evidence of these animals has been observed at the mine site, but black bear and mountain lion are known to occupy habitats on Bull Mountain north of the existing permit boundary. Moose are known to occupy the riparian habitats of the Jefferson and Boulder Rivers south and east of the mine (GSM 1995b, Volume 2, Appendix 3.4-1).

III.E.1.c Bats and Other Small Mammals

Several bat species found in Montana use abandoned mines for roost sites, including winter hibernacula. Bat surveys conducted by GSM in 1995 identified several unknown species of myotis and big brown bats flying in the vicinity of the mine. A fringed myotis (*M. thysanodes*) was captured during the surveys and released. Five hibernating big brown bats were observed in one of the four abandoned mines surveyed. No additional hibernacula could be found, but it is possible that additional bat hibernacula or nursery colonies may be present, since dangerous conditions precluded extensive surveys in almost all of the abandoned mines present (GSM 1995b, Volume 2, Appendix 3.4-1).

Other small mammal species known to occur within proposed disturbance areas include: snowshoe hare, white-tailed jackrabbit, Nuttall's cottontail rabbit, yellow-bellied marmot, yellow pine and least chipmunk, Columbian ground squirrel, red squirrel, bushy-tailed woodrat, northern pocket gopher, porcupine, and striped skunk (MDSL and BLM 1980; GSM 1995b, Volume 2, Appendix 3.4-1). Several species of mice and vole also occupy the proposed disturbance area. Coyote, badger, and bobcat are common predators throughout the region, and are likely to hunt other small mammals in the vicinity of the mine (MDSL and BLM 1990; GSM 1995b, Volume 2, Appendix 3.4-1).

III.E.1.d Upland Game Birds and Other Land Birds

Sharp-tailed grouse, mourning dove, and gray (Hungarian) partridge are the only upland game birds that have been recorded in the immediate vicinity of the mine site (GSM 1995b, Volume 2, Appendix 3.4-1). GSM introduced wild turkey in the riparian woodlands along the Jefferson River south of the mine (Smith 1995). During field surveys, twelve raptor species have been observed flying over or roosting in the vicinity of the mine. These species include the bald eagle, golden eagle, turkey vulture, rough-legged hawk, red-tailed hawk, northern harrier, northern goshawk, sharp-shinned hawk, merlin, American kestrel, great-horned owl, and saw-whet owl (GSM 1995b, Volume 2, Appendix 3.4-1; ENSR 1995). Raptor nest surveys conducted in April and May of 1994 located one stick nest in a large limber pine north of the tailings impoundments. This nest did not appear active in 1994 or 1995, but a pair of red-tailed hawks were occasionally seen on or near the nest (GSM 1995b, Volume 2, Appendix 3.4-1). Table III-3 summarizes the terrestrial bird species recorded in the vicinity of the mine. The majority of these species potentially nest in the area (MDSL and BLM 1990).

Long-term downward trends in many bird populations, including some neotropical migratory bird species and resident song birds have been documented in North America. Because of these data, land management agencies and others have begun to emphasize evaluating population trends of many species of land birds and taking steps to conserve important or unique habitats. In Montana, the State Partners in Flight (MTPIF) Committee, an interagency scientific group, has developed a draft state list of priority bird species. This priority list places bird species of concern into four categories (see Table III-3 footnote). Based on the preliminary bird species list compiled for the Golden Sunlight Mine project vicinity, there are at least 9 species present that occur on the MTPIF priority list (Table III-3).

III.E.1.e Waterfowl, Waders, and Shorebirds

Waterfowl use of the Jefferson and Boulder Rivers is substantial, and documentation of waterfowl at the mine site includes observations of birds flying over the study area and extensive records of birds attempting to land on the tailings ponds. Waterfowl documented at or over the mine site in 1995 include 619 Canada geese and 2,128 white pelicans (GSM 1995b, Volume 2, Appendix 3.4-1). The area also is a major migration corridor for swans and snow geese (MDSL and BLM 1990). Common mergansers and mallards have been observed immediately south of the mine site near the Jefferson River. Approximately 100 killdeer and 2,500 American avocets were observed on the sand flats near the tailings ponds in 1995. Long-billed curlews, sandhill cranes, and great blue herons have been observed flying overhead and feeding and courting south of the mine site near the Jefferson River (GSM 1995b, Volume 2, Appendix 3.4-1).

III.E.1.f Reptiles and Amphibians

Three species of snakes have been observed at the mine site in xeric shrub/grassland, open grassland, and rock habitats. These include the prairie rattlesnake, gopher snake, and western racer (GSM 1995b, Volume 2, Appendix 3.4-1). Bull snakes also are thought to be common in the area (MDSL and BLM 1990). No amphibians are known to exist in the general vicinity of the mine. Trout (1988) identified the probable presence of the plains spadefoot, eastern short-horned lizard, rubber boa, and plains hognose in the vicinity of the existing Golden Sunlight Mine.

III.E.2 Fisheries Resources

No perennial streams are located within the proposed disturbance or proposed permit boundaries, and no aquatic fisheries habitat is present within these areas. The nearby

Jefferson and Boulder Rivers provide the nearest fisheries habitat. Both rivers are characterized by four dominant groups of macroinvertebrates: stoneflies, mayflies, caddisflies, and true flies (GSM 1995b, Volume 2, Appendix 3.4-2). Stoneflies are the most abundant group in the Boulder River, while mayflies are the most abundant group in the Jefferson River.

The aquatic habitat and fisheries resources in the Jefferson River have been affected by irrigation and municipal uses. During summer, dewatering for irrigation causes increased water temperatures that are potentially lethal to trout. Effluent from the sewage treatment facility for Whitehall is released into the Jefferson Slough, but may migrate via underground seepage into the Jefferson River (GSM 1995b, Volume 2, Appendix 3.4-2). Nevertheless, the Jefferson River near the Golden Sunlight Mine is rated a high quality stream, and it maintains a fishery composed of brown and rainbow trout, mountain whitefish, white sucker, longnose sucker, carp, and burbot. A 3-year average population survey estimated 283 adult (3 years+) brown trout/mile below the mine site (Willow Creek to Three Forks) and 350 adult brown trout/mile above the mine site (Hells Canyon Creek section) (MDSL and BLM 1980).

The aquatic habitat and fisheries resources in the Boulder River have been influenced by road construction, mining, and agriculture. Construction of roadways has shortened the river's length and destroyed bank stabilizing riparian vegetation, thereby accentuating erosion of abandoned mine tailings containing zinc and copper upstream of the mine near Boulder, Montana. Irrigation withdraws water from the river to the extent that a 20-mile reach of the river does not contain enough water to support an optimal fishery (GSM 1995b, Volume 2, Appendix 3.4-2). Fish populations increase towards the mouth of the river, where water quality is more favorable for aquatic life. Brown, brook, and rainbow trout; mountain whitefish; white sucker; longnose sucker; and possibly golden shiner are present in the Boulder River, and the river has been designated a substantial sports fishery for the stretch from Cottonwood Creek to the Jefferson River (Trout 1989; GSM 1995b, Volume 2, Appendix 3.4-2). The lower Boulder River is used for spawning by brown trout (MDSL and BLM 1980).

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Table III-3

Land Birds Known to Occur in the Vicinity of the Golden Sunlight Mine

Species	Occurrence in the Vicinity of the Golden Sunlight Mine	State Priority List Category
Rock dove	B, W	
Common nighthawk	B	
Northern flicker	B, W, R	
Hammond's flycatcher	B	II
Dusky flycatcher	B	
Eastern kingbird	B	
Horned lark	B, W, R	
Pinyon jay	N/A	
Clark's nutcracker	B, W, R	
Black-billed magpie	B, W, R	
Common raven	B, W, R	
Mountain chickadee	B, W, R	
Red-breasted nuthatch	B, W, R	
White-breasted nuthatch	B, W, R	
Brown creeper	B, W, R	I
Rock wren	B	
Mountain bluebird	B	
Townsend's solitaire	B, W, R	III
Swainson's thrush	B	
American robin	B	
Cedar waxwing	B, W, R	
Solitary vireo	B	III
Yellow warbler	B	
Yellow-rumped warbler	B	
Lazuli bunting	B	III
Green-tailed towhee	B (on border of breeding range)	
Spotted-sided towhee	B	
American tree sparrow	W	

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Table III-3 (Continued)

Species	Occurrence in the Vicinity of the Golden Sunlight Mine	State Priority List Category
Chipping sparrow	B	
Brewer's sparrow	B	II
Vesper sparrow	B	
Lark sparrow	B	III
Song sparrow	B (potential wintering grounds)	
Dark-eyed junco	B, W, R	
Western meadowlark	B, W, R	
Brewer's blackbird	B	
Brown-headed cowbird	B	
Cassin's finch	B, W, R	
Pine siskin	B, W, R	
Sharp-tailed grouse	B, W, R	
Mourning dove	B	
Gray partridge	B, W, R	
Turkey	B, W, R	
Bald eagle	B, W, R	II
Golden eagle	B, W, R	
Turkey vulture	B	
Rough-legged hawk	W	
Red-tailed hawk	B, W, R	
Northern harrier	B, W, R (does not breed/winter at higher elevations)	
Northern goshawk	B, W, R	II
Sharp-shinned hawk	B, W, R	
Merlin	B, W	
American kestrel	B, W, R	
Great-horned owl	B, R	
Saw-whet owl	B, W, R	

Source: GSM 1995b, Volume 2, Appendix 3.4-1.

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Table III-3 (Continued)

KEY:

R = Resident
B = Potential breeder
W = Wintering

NA = Not Available

MTPIF Priority List Categories:

I: Species for which Montana should formulate conservation actions.

II: Species-in-need for which we have responsibility, but with lesser threat or stable/increasing populations in state.

III: Species of local interest or concern. Presence of these species may serve as added criteria in the selection of conservation strategies.

IV: Formerly suggested for inclusion on state list, but recommended for deletion because of various factors.

III.F THREATENED, ENDANGERED, AND CANDIDATE SPECIES

The proposed project region contains a variety of habitat types that may support sensitive wildlife resources; wildlife habitats in the mine vicinity are discussed in Section III.E, Wildlife and Fisheries Resources. However, no federally threatened, endangered or proposed; federal candidate; or other sensitive species reside within the mine area, and relatively few sightings of these species have been recorded near the mine site. Table III-4 lists the sensitive species that were considered for this proposed project, based on existing data.

A Biological Assessment has been prepared for the proposed Golden Sunlight Mine expansion project, in accordance with Section 7(c) of the Endangered Species Act, to determine if any sensitive plant or animal species may be impacted by the Proposed Action. Section 7 requires that all federal agencies, in consultation with the USFWS, ensure that their actions do not jeopardize the continued existence or adversely modify the critical habitat of federally listed or proposed species. The BLM, as federal co-lead agency, requested a species list under informal Section 7 Consultation from the USFWS, Helena Ecological Services Office. Additional species data were requested from the Montana Natural Heritage Program (MNHP) and the MDFWP. The list provided by USFWS contains five federally listed and two federal candidate species that potentially occur in the proposed project area.

The Biological Assessment analysis focused on the five federally listed and two federal candidate species identified by the USFWS, as well as an additional five BLM sensitive species identified as potentially occurring in the mine vicinity. BLM sensitive species are defined as those formerly classified by the USFWS as candidate-category 2 species prior to the Notice of Review published in the Federal Register on February 28, 1996, which omitted the category 2 listing. Since the BLM's current policy manages sensitive species to prevent future federal listing as threatened or endangered, the BLM continues to protect the previous category 1 and category 2 species in Montana that are not presently included in the USFWS' new candidate listing.

Data sources consulted for this assessment included information from federal and state agencies, federal recovery plans, published literature, and direct correspondence with federal and state agency personnel. Field surveys for plant and animal species were conducted in proposed disturbance areas in 1988, 1991, 1993, 1994, and 1995 (Trout 1988; GSM 1995b, Volume 2, Appendix 3.4-1). The following baseline descriptions are limited to species that have been surveyed or that could be impacted by the Proposed Action. Detailed species' descriptions presented in the Biological Assessment (Appendix E) include discussion of each specie's status, distribution, life history, habitat associations, endangerment, and likely presence in the project area.

III.F.1 Mammals

The gray wolf (*Canis lupus*) is federally listed as endangered throughout the lower 48 states, except Minnesota. However, the Golden Sunlight Mine is located within the designated Yellowstone gray wolf experimental population area; wolves occurring within this area are classified as federally proposed for listing.

Wolf habitat is defined as including: 1) an adequate year-round prey base, 2) suitable and somewhat secluded denning and rendezvous sites, and 3) sufficient range with minimal exposure to humans (USFWS 1987). The species has recently been reported in the vicinity of Emigrant, Montana, approximately 80 miles southeast of the mine. The nearest known wolf occurrence is in the Elkhorn Mountains between Boulder and Deerlodge, Montana, approximately 50 miles northwest of the mine (Fontaine 1996). No wolves have been reported to occur in the immediate mine vicinity. Although the general mine vicinity is characterized by a higher degree of human development than the gray wolf generally tolerates, occasional transitory wolves could occur in the area if relocation efforts continue to increase wolf populations in the region.

Table III-4

Special Status Species for the Golden Sunlight Mine Project

Common Name	Scientific Name	Status[1]	Habitat Description	Occurrence in the Area
BIRDS				
Peregrine falcon	*Falco peregrinus*	F-E[2]	Cliffs 150 feet or greater in height, close proximity to water where avian prey species are abundant, and isolation from human disturbance	No roosting or nesting habitat; may forage in vicinity
Bald eagle	*Haliaeetus leucocephalus*	F-T	Occur in association with major rivers, lakes, and reservoirs; nesting habitat requires large trees in proximity to open water with an adequate food source of fish and waterfowl	No roosting or nesting habitat; may forage in vicinity
Mountain plover	*Charadrius montanus*	F-C	Flat, shortgrass prairie, and prairie dog colonies in mid- and tall-grass prairie ecosystems; suitable habitat often occurs in intensively grazed areas	Potential habitat exists in Section 16, downstream of diversion, and open meadows east of the proposed disturbance areas
Ferruginous hawk	*Buteo regalis*	BLM-S	Nesting sites include trees, ledges, rock outcrops, and low cliffs in shrub and grassland communities	Not documented in the project area but suitable habitat exists
Northern goshawk	*Accipiter gentilis*	BLM-S	Subalpine fir, Engelmann spruce, Douglas-fir, and ponderosa pine forests; nests in large older trees in dense forest stands	Not likely to occur; occasional foraging or migrating
Trumpeter swan	*Cygnus buccinator*	BLM-S	Open water with appropriate aquatic plants	Documented occurrences near the tailings impoundments

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Table III-4 (Continued)

Common Name	Scientific Name	Status[1]	Habitat Description	Occurrence in the Area
MAMMALS				
Gray wolf	Canis lupus	F-N	Variety of habitat types characterized by secluded denning and rendezvous sites, and sufficient range with minimal exposure to humans	Not likely to occur
Grizzly bear	*Ursus arctos horribilis*	F-T	Alpine and subalpine coniferous forests; minimal exposure to humans	Not likely to occur
Fringed myotis	*Myotis thysanodes*	BLM-S	Variety of vegetation types, including coniferous forest, mixed shrub, sagebrush, riparian, and cropland; roosts in caves, mines, and buildings	Known to occur
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	BLM-S	Desert shrublands, coniferous forest, and mixed grass prairies; roosts in trees, caves, and man-made structures; hibernacula requires stable temperatures	Known to occur
Western small-footed myotis	*Myotis ciliolabrum melanorhinus*	BLM-S	Woodlands and desert communities, rocky areas; roosts in caves, abandoned buildings, under rocks, in crevices, and under pine bark	Unknown occurrence
Long-eared myotis	*Myotis evotis*	BLM-S	Coniferous forests and mixed woodlands, 6,000 to 9,000 feet; roosts in caves, mine tunnels, lava beds, and buildings	Unknown occurrence
Long-legged myotis	*Myotis volans*	BLM-S	Ponderosa pine and mixed conifer; roosts in caves, man-made structures, and rock crevices	Unknown Occurrence
Spotted bat	*Euderma maculatum*	BLM-S	Cliffs near perennial water and other habitats, including riparian, piñon-juniper, woodlands, and ponderosa pine forest; roosts in crevices and cracks in cliffs or under loose rocks	Unknown Occurrence
Yuma myotis	*Myotis yumanensis*	BLM-S	Desert grassland, woodland, and riparian areas from 4,000 to 7,000 feet; roosts in buildings, caves, and crevices	Unknown Occurrence

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Table III-4 (Continued)

Common Name	Scientific Name	Status[1]	Habitat Description	Occurrence in the Area
PLANTS				
Ute ladies'-tresses	*Spiranthes diluvialis*	F-T	Perennial orchid associated with moist soils in wet or mesic meadows	Not likely to occur

Sources: MNHP 1995.

[1] Federal:

F-E Federally listed as endangered: A species in danger of extinction throughout all or a significant portion of its range.

F-T Federally listed as threatened: A species likely to become endangered within the foreseeable future through all or a significant portion of its range.

F-C Candidate: Sufficient information on biological vulnerability exists to support proposals to list as endangered or threatened species.

BLM-S Formerly Candidate - Category 2: The USFWS has discontinued the designation of Category 2 species as candidates for listing (Federal Register: February 28, 1996. Pages 7595-7613).

F-N Nonessential: Population classified as experimental and nonessential for the designated recovery area.

[2] Currently proposed to be delisted; final decision is pending.

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The grizzly bear (*Ursus arctos*) is federally listed as threatened. The grizzly prefers dense forest habitat, but will go where it best can meet its food requirements (USFWS 1993). Currently, 5 areas within the lower 48 states contain grizzly bear populations. Golden Sunlight Mine is located approximately 110 miles east of the Selway-Bitterroot and approximately 75 miles north of the Yellowstone grizzly bear ecosystems identified in the 1993 USFWS Grizzly Bear Recovery Plan. The species recently has been reported in the Tobacco Root and Gravelly Mountains south of the mine area. The most recent unconfirmed grizzly bear sighting occurred in the Elkhorn Mountains approximately 50 miles northeast of the mine (Vandehey 1996). Although the immediate surrounding area is not characterized by dense vegetation and the grizzly bear has not been reported in the vicinity of Golden Sunlight Mine, it is possible that an occasional transient bear could occur in the mine vicinity, based on the solitary and wandering nature of the species.

Several sensitive bat species occur in Montana and could occupy roosting sites or foraging habitats in and near the mine area. Approximately 70 open mine workings exist in the proposed project area, but relatively few are characterized as appropriate bat habitat. Several abandoned mine workings located northwest of the open pit were surveyed for evidence of hibernacula in February 1995 (GSM 1995b, Volume 2, Appendix 3.4-1). These workings included the main Florence, the east extension of the Florence, the White Dog, the Surprise East and West, and the lower and upper entrances to the Lucky Heat in Section 18, and two entrances to the Sunny Corners workings in Section 24. Five big brown bats were found hibernating in the main Florence workings. In addition, several unidentified *Myotis* were observed feeding in the area and one fringed myotis was captured during a survey conducted on August 22, 1995. Additional shaft and adit surveys in other workings were not conducted due to unsafe working conditions. The surveyed shafts and adits represent the most extensive workings in the vicinity of the proposed mining activities.

Although not as extensive, other workings in the project area also could be utilized by bats. These workings include an unnamed adit within the Amex 27 claim in Section 19 and the Gold Crown #2 shaft, Steppan Sulfide adit, and the Gold Bug shaft in section 24 (Chadwick 1996). Potential foraging areas associated with water in the project area include open water in the pit, tailings impoundments, and seven small springs and seeps (see Section III.B, Water Resources). A number of bat species are foliage gleaners in both riparian and upland habitats. Potential roosting or foraging habitat may occur within the proposed project area for seven species, including the fringed myotis, western small-footed myotis, Yuma myotis, long-legged myotis, long-eared myotis, spotted bat, and Townsend's big-eared bat; however, some of these habitats would be considered marginal to support these species. The detailed background information and the potential for occurrence pertaining to two of these species, the fringed myotis and the Townsend's big-eared bat, is presented in the Biological Assessment (Appendix E). The potential impacts to bat habitat discussed in Chapter IV, Section IV.F, Threatened, Endangered, and Candidate Species, would apply to any bat species occupying the mine area.

III.F.2 Birds

The bald eagle (*Haliaeetus leucocephalus*), federally listed as threatened, and the peregrine falcon (*Falco peregrinus*), federally listed as endangered, are both known to occur in the vicinity of the Golden Sunlight Mine. Both species may migrate through the area, and bald eagles are known to winter along the Jefferson and Boulder Rivers. No evidence of nesting bald eagles or peregrine falcons was found in the vicinity of the Proposed Action during raptor nest searches (GSM 1995b, Volume 2, Appendix 3.4-1). However, both species are likely to hunt or forage within the mine area. Due to the abundance of available hunting and foraging habitat in the region, the bald eagle and peregrine falcon most likely use the mine area on a seasonal, occasional, and short-term basis.

The northern goshawk (*Accipiter gentilis*), a BLM-sensitive species, is associated with a variety of forest types, including ponderosa pine, Engelmann spruce, subalpine fir, and Douglas-fir/white-fir mixed with blue spruce and aspen. This species typically nests in dense woodland areas, including old-growth forests. Habitat associated with the proposed project area is not characterized as preferred habitat for the northern goshawk. However, this species has been documented near the mine vicinity (GSM 1995b, Volume 2, Appendix 3.4-1) and could forage over the mine area on a migratory and seasonal basis.

The mountain plover (*Charadrius montanus*) is a federal candidate species. Mountain plovers mainly inhabit high plains and semi-desert regions of the western United States. The species prefers flat, shortgrass prairie and tends to avoid taller grasses and hillsides. The mountain plover has been sighted in heavily grazed grassland in the Whitetail Creek drainage approximately 2 miles west of the mine area (MNHP 1995). Potential plover habitat occurs immediately east of the mine in a heavily grazed pasture (Knowles 1995). Mountain plovers could occupy grassland and pasture areas within the proposed permit boundary.

The ferruginous hawk (*Buteo regalis*), a BLM-sensitive species, is associated with sagebrush-grass, grassland, mesic meadow, and riparian communities. This species typically nests on rock outcrops, promontory points, low cliffs, and trees along riparian areas. Nesting habitat consists of communities with isolated trees, woodland edges, buttes, cliffs, and grassland with some relief. Although this species has not been documented at the mine site, likely habitat does occur in the area.

The trumpeter swan (*Cygnus buccinator*), also a BLM sensitive species, requires water sources that are rich in aquatic life. No known nest sites or foraging areas exist in the immediate mine area. However, potential habitat does occur along the nearby Jefferson and Boulder River Valleys, and the species has been documented near the tailings impoundments (GSM 1995a).

III.F.3 Plants

The Ute ladies'-tresses (*Spiranthes diluvialis*) is federally listed as threatened. This perennial, terrestrial orchid occurs in riparian meadows characterized by vegetation that is not overly dense, overgrown, or overgrazed. This species has been observed in the Piedmont Swamp approximately 4 miles south of the Golden Sunlight Mine. Piedmont Swamp is a 500-acre wetland acquired by GSM in 1991. The Ute ladies'-tresses was discovered in this area during baseline vegetation studies conducted by MNHP as part of GSM's habitat restoration and enhancement program (Heidel 1995). However, the Ute ladies'-tresses has not been documented in the proposed project area (GSM 1995b, Volume 2, Appendix 3.4-1).

III.F.4 Fish

The bull trout (*Salvelinus confluentus*), a federal candidate species, was included on the USFWS species list for this project. However, the bull trout does not occur in the project area or nearby fisheries, and therefore is not analyzed further in this document.

III.G AIR QUALITY

III.G.1 Climatology

Although climatologically variable due to differences in elevation, the overall regional climatology pertinent to the Golden Sunlight Mine is classified as cold steppe BSk by the Trewartha climatological classification system (Trewartha and Horn 1980).

The climate is characterized mostly by the lack of precipitation in comparison to the regional potential evaporation. This is due to the mine's proximity to the Rocky Mountains to the west. The latitude in which the Golden Sunlight Mine lies is within the prevailing westerlies, where the dominant flow pattern is west to east. The Rocky Mountains are generally oriented north-south throughout this region, and create an orographic barrier in which these westerly winds force air up and over the mountains. As air is forced up the western slopes, it cools and moisture is condensed out of the air. As the air descends down the eastern slopes, it is compressed and subsequently warmed. The relative humidity drops dramatically due to this warming of the air, which has already had most of the moisture condensed from it. Hence, to the east of these mountains, as where the mine is located, conditions are typically dry and windy.

Climatological records spanning a 30-year period from 1965 through October 1995, for Butte, Montana, indicate an average precipitation of 12.81 inches. These data are provided in Table III-5 and are representative of the region where the Golden Sunlight Mine is located. The summer months bring the most precipitation, with average monthly values higher than 1.25 inches from May through September. Occasional thunderstorms can deliver brief, moderate to heavy rainfall, and may account for the increased precipitation. The fall, winter, and early spring months (October through April) average less than 1 inch of precipitation per month, and much of this is in the form of snow. Annual precipitation values for Butte are compared to the average values over the period from 1965 to 1995, and are presented graphically in Figure III-14.

Summers are typically mild, with maximum daytime temperatures averaging in the upper 70s to low 80s, although some very hot days can occur with temperatures into the 90s. Lows during the summer months are cool, with nighttime minimum temperatures generally in the 40s. This large diurnal variation is attributable to the low relative humidities within the region during this time of year. Winters can be very cold, with the mean maximum temperature for January near 30°F, and mean minimum temperatures between 5° to 10°F.

The Rocky Mountain region tends to be quite windy throughout the year. During the summer, thunderstorms are typical, and can be accompanied by high winds generated through the evaporative cooling process. The air below these storms is usually quite dry, and as precipitation falls from the storms into the dry layer of air below, it evaporates. As the moisture evaporates, heat is removed from the air, resulting in a cool, more dense airmass below the storm, as compared to the surrounding airmass. The density difference causes the air below the storm to be heavier than the surrounding air and, therefore, it falls more rapidly toward the ground. Upon hitting the ground, the air spreads out, and can cause very strong winds. Occasionally, this air hits the ground at tremendous speeds (100+ miles per hour) and is known as a "microburst." Winter brings large low pressure systems across the region, and because of the steep pressure gradients typically found with these storms, very strong winds are common.

Winds around the Golden Sunlight Mine also are influenced by the orographic effects of the terrain. Drainage winds can occur at night as cool air spills into low lying areas. Also, mountains and buttes can act to funnel air, increasing wind speeds as air is forced between orographic barriers.

Meteorological monitoring at the Golden Sunlight Mine indicate a predominant westerly wind of moderate (10 to 15 miles per hour [mph] average) intensity throughout the year.

Table III-5

Golden Sunlight Mine - DEIS
Butte, Montana, Climatological Data 1965 - 1995

Precipitation

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual Total
1965	0.44	0.27	0.58	1.00	1.35	3.58	0.70	2.49	2.24	0.37	0.37	0.32	13.71
1966	0.28	0.31	0.30	0.33	0.82	2.37	0.24	0.50	1.62	0.49	0.41	0.48	8.15
1967	0.45	0.18	1.05	2.56	2.96	3.78	0.52	0.24	1.02	2.24	0.34	0.67	16.03
1968	0.93	0.06	0.57	0.96	1.67	2.43	0.22	2.36	2.08	0.35	0.96	0.28	12.87
1969	1.65	0.23	0.22	1.31	2.20	5.80	2.36	0.43	0.71	0.36	0.15	0.19	15.61
1970	0.35	0.30	1.07	0.39	1.13	1.59	2.07	0.47	1.79	0.56	0.84	0.28	10.84
1971	0.71	0.29	0.88	1.01	1.64	1.94	0.20	1.11	0.92	0.52	0.46	0.72	10.40
1972	1.10	0.26	1.39	0.36	0.64	1.23	0.78	1.24	0.42	0.26	0.17	0.51	8.36
1973	0.16	0.75	0.29	0.64	0.90	2.15	0.38	0.50	0.73	0.96	0.71	0.65	8.82
1974	0.17	0.31	0.88	0.12	1.82	0.29	0.51	1.95	0.42	0.80	0.46	0.58	8.31
1975	1.40	0.56	0.75	2.46	1.66	1.87	3.49	1.95	0.47	3.06	0.53	0.42	19.62
1976	0.16	0.38	0.33	0.54	1.29	3.27	0.85	2.40	2.04	0.22	0.15	0.07	11.80
1977	0.78	0.04	0.69	0.67	1.61	1.78	1.84	1.34	3.15	0.59	0.49	0.82	13.80
1978	0.26	0.67	0.54	1.36	2.01	0.72	2.41	1.20	2.43	0.10	0.42	0.48	12.60
1979	0.40	0.50	0.53	1.93	0.46	0.92	0.37	1.92	0.09	0.52	0.40	0.21	8.25
1980	0.52	0.65	0.91	1.45	4.49	4.62	1.27	1.39	2.33	1.06	0.71	0.21	19.61
1981	0.07	0.47	1.04	1.00	4.81	1.81	1.01	0.44	0.81	0.85	0.91	0.36	13.58
1982	0.82	0.40	1.84	0.88	1.67	2.95	0.75	0.40	1.44	0.63	0.30	0.75	12.83
1983	0.14	0.16	0.91	0.57	0.98	1.75	2.95	2.40	1.21	0.59	0.33	0.56	12.55
1984	0.34	0.50	0.71	1.06	1.37	2.78	0.66	1.41	0.68	0.58	0.62	0.26	10.97
1985	0.17	0.34	0.69	0.18	1.66	1.22	0.33	1.52	1.77	0.76	0.64	0.21	9.49
1986	0.28	0.89	0.86	1.71	0.98	1.64	1.45	1.79	2.50	0.26	1.34	0.11	12.81
1987	0.23	0.50	0.87	0.26	3.88	0.50	4.18	1.51	0.07	0.00	0.16	0.64	12.80
1988	0.47	0.18	0.55	1.15	2.01	0.75	0.33	0.15	1.11	0.42	0.59	0.61	8.32
1989	1.30	0.72	1.21	0.89	1.74	0.81	1.89	1.64	1.48	1.08	0.41	0.58	13.75
1990	0.46	0.11	0.63	0.71	2.18	1.17	0.92	2.32	0.07	0.26	0.62	0.34	9.81
1991	0.45	0.15	1.36	Missing	2.36	2.38	Missing	0.90	1.48	0.70	0.82	0.38	10.98
1992	0.41	0.20	0.59	0.28	0.95	4.05	1.58	0.65	0.58	1.37	0.58	0.36	11.60
1993	0.60	0.67	0.43	1.70	1.82	4.30	3.05	3.10	0.14	1.26	0.31	0.57	17.95
1994	0.10	0.40	0.25	1.18	2.48	1.44	2.18	0.22	0.09	1.73	1.50	0.51	12.08
1995	0.53	0.53	1.14	1.48	2.06	4.62	3.37	0.52	2.18	0.70	Missing	Missing	17.13
Average	0.54	0.40	0.80	0.97	1.92	2.35	1.43	1.35	1.27	0.79	0.56	0.44	12.81
Maximum	1.65	0.89	1.84	2.56	4.81	5.80	4.18	3.10	3.15	3.06	1.50	0.82	19.61
Minimum	0.07	0.04	0.22	0.12	0.46	0.29	0.20	0.15	0.07	0.00	0.15	0.07	8.15

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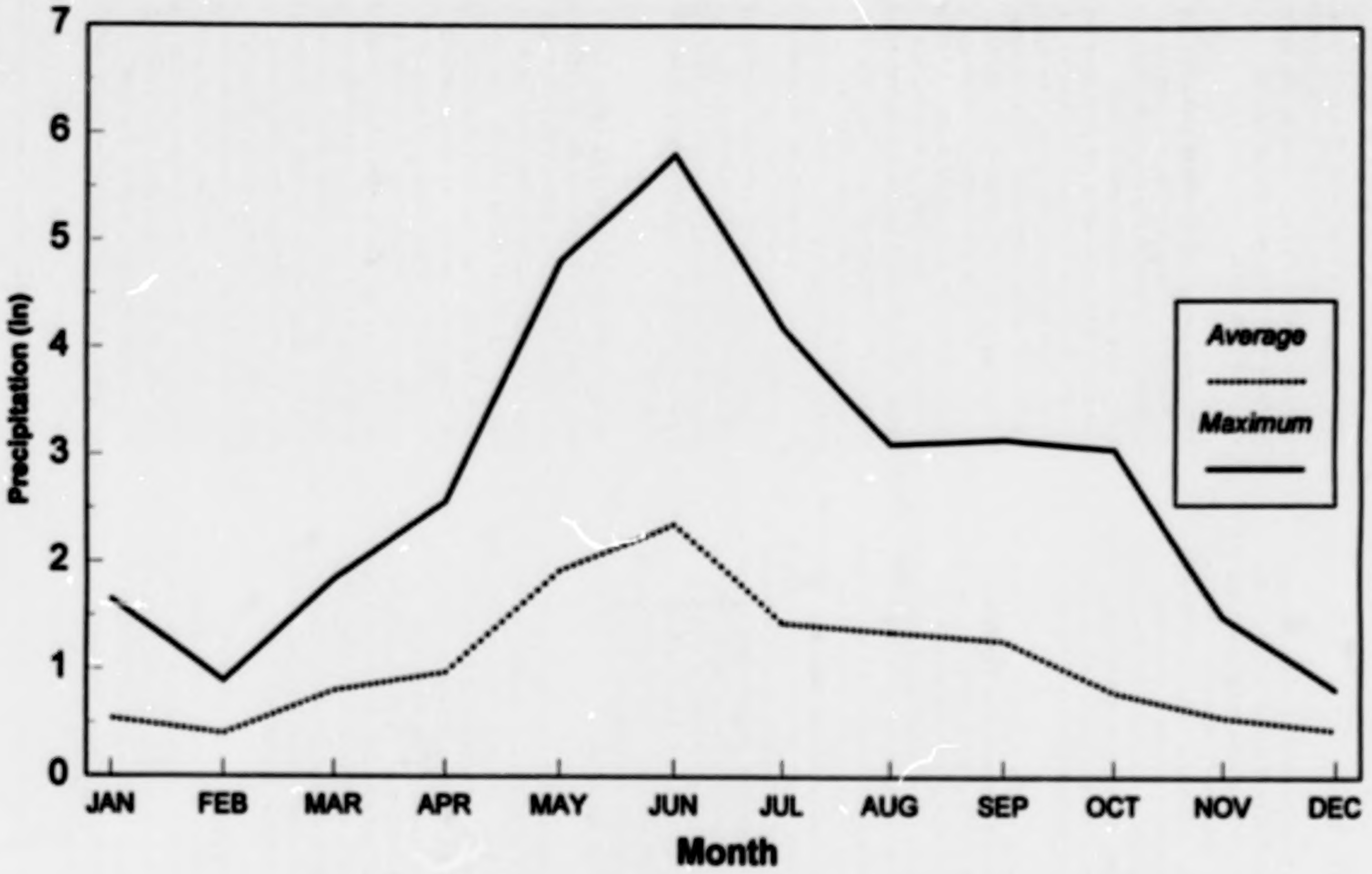

FIGURE III-14 AVERAGE AND MAXIMUM PRECIPITATION AT BUTTE 1965-1995

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III.G.2 Air Quality

The Golden Sunlight Mine lies within an area which is classified by the MDEQ as "unclassified" for all criteria pollutants, based on a system of "attainment," "non-attainment," and "unclassified." Attainment refers to whether the region is attaining the Ambient Air Quality Standards (AAQS), non-attainment if the region is not attaining the AAQS, and unclassified if the region does not have sufficient data to support either of the aforementioned classifications.

The principal air quality protection mechanism under the Federal Prevention of Significant Deterioration (PSD) program involves a system of area classifications that define significant deterioration for individual pollutants. Areas of special national concern where the need to prevent significant deterioration is the greatest are designated Class I areas. Class I areas include all national parks and national wilderness areas. Less restrictive rules apply in areas designated as Class II, which the Golden Sunlight Mine falls into. Several Class I areas are located within 100 miles of the Golden Sunlight Mine, the most notable of which is Yellowstone National Park, approximately 90 miles to the southeast. However, no Class I areas are expected to be affected by the proposed mine operations.

Federal and state of Montana AAQS determine the maximum allowable concentrations of air pollutants in areas accessible to the public. The AAQS for the types of emissions anticipated from the Golden Sunlight Mine proposed operations are presented in Table III-6, Summary of Ambient Air Quality Standards. This summary includes the standards for carbon monoxide (CO), nitrogen dioxide (NO_2), SO_2, ozone (O_3), and particulate matter emissions, especially particulate matter less than, or equal to, 10µm in aerometric diameter (PM_{10}).

The AAQS are applied to air pollutants exhibiting known detrimental health effects to humans, and are traceable to direct emissions from a known source (CO, SO_2, PM_{10}), or from chemical reactions of emitted pollutants in the ambient air (NO_2, O_3, PM_{10}). The former emissions are referred to as "precursor" emissions, and the latter class of pollutants as "secondary" emissions. It is difficult to regulate secondary emissions and, therefore, regulatory agencies focus their efforts more on the precursor pollutants.

Although emissions of all criteria pollutants are possible from mining activities, the primary pollutant of concern at the Golden Sunlight Mine is particulate matter emitted from operations such as blasting, stripping, crushing, and the movement of vehicles on unpaved roads. GSM has conducted ambient air quality monitoring on-site since 1980. Three stations are located on the mine property; two monitor air quality (PM_{10}) and the other meteorology. These stations range in elevation from 4,748 feet above mean sea level (AMSL), to 5,000 feet AMSL. Data provided by this monitoring activity indicates that concentrations of PM_{10} over the monitoring period have been within the limitations of the AAQS. The highest 24-hour level of particulate concentrations occurred in 1991 with a measurement of 103 $\mu g/m^3$ compared to the national and state standard of 150 $\mu g/m^3$. The highest annual average particulate concentrations occurred in 1994 with a value of 15 $\mu g/m^3$ compared to the AAQS of 50 $\mu g/m^3$.

The ambient levels of particulate matter within the region are attributable not only to the mining activities at the Golden Sunlight Mine, but also to the fact that the region does experience frequent high winds and is typically quite dry. These high winds can pick up surface dust and can transport the smaller and lighter particles long distances, creating short-term impacts to local air quality. For example, on October 10, 1996, strong winds transported a large cloud of tailings dust out of the tailings impoundment. These tailings typically contain small quantities of heavy metals and/or cyanide. No monitoring devices were present near the tailings pond and, therefore, no analysis of the tailings dust was performed on that day to determine the constituent material. However, GSM operates PM_{10} particulate monitoring equipment due east (downgradient of the prevailing wind direction) of Impoundments No. 1 and 2. The total particulate matter obtained and analyzed during routine monitoring has not detected elevated concentrations of heavy metals.

Following this event, GSM took action to mitigate the potential for future similar situations. Personnel from the MDEQ visited the mine on October 11, 1996, to discuss the situation and determine the extent of necessary remedial action. GSM applied Coherex, a coagulating substance that binds the smaller tailings particles into larger particles which are less prone to transport during strong wind events. GSM then applied a thin layer of gravel over the top of as much of the tailings as possible. The entire tailings pile will be capped with over 5.5 feet of cover material beginning in consolidated areas in 1997. This measure is expected to minimize the potential for similar events at the tailings impoundments in the future.

Table III-6

Summary of Ambient Air Quality Standards

		Montana Standards	National Standards[1]	
Pollutant	Averaging Time	Concentration[2]	Primary[3]	Secondary[4]
Sulfur Dioxide (SO_2)	Annual Arithmetic Mean	50 $\mu g/m^3$ (0.02 ppm)	80 $\mu g/m^3$ (0.03 ppm)	—
	24 hours	260 $\mu g/m^3$ (0.10 ppm)	365 $\mu g/m^3$ (0.14 ppm)	—
	3 hours	—	—	1,300 $\mu g/m^3$ (0.5 ppm)
	1 hour	1,300 $\mu g/m^3$ (0.5 ppm)	—	—
Inhalable Particulate (PM_{10})	Annual Arithmetic Mean	50 $\mu g/m^3$	50 $\mu g/m^3$	Same as Primary Standards
	24 hours	150 $\mu g/m^3$	150 $\mu g/m^3$	Same as Primary Standards
Ozone (O_3)	1 hour	195 $\mu g/m^3$ (0.10 ppm)	235 $\mu g/m^3$ (0.12 ppm)	Same as Primary Standards
Carbon Monoxide (CO)	8 hours	10,000 $\mu g/m^3$ (9.0 ppm)	10,000 $\mu g/m^3$ (9.0 ppm)	Same as Primary Standards
Carbon Monoxide (CO)	1 hour	26,000 $\mu g/m^3$ (23.0 ppm)	40,000 $\mu g/m^3$ (35 ppm)	Same as Primary Standards
Nitrogen Dioxide (NO_2)	Annual Arithmetic Mean	100 $\mu g/m^3$ (0.05 ppm)	100 $\mu g/m^3$ (0.05 ppm)	Same as Primary Standards
	1 hour	560 $\mu g/m^3$ (0.30 ppm)	—	—

[1] National standards, other than those based on annual averages or annual geometric means, are not to be exceeded more than once per year.

[2] Concentrations are expressed first in micrograms per cubic meter ($\mu g/m^3$), and are based upon a reference temperature of 25°C and a reference pressure of 760 mm of mercury; ppm in this table refers to parts per million (ppm) by volume, or micromoles of pollutant per mole of gas.

[3] National Primary Standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health. Each state must attain the primary standards no later than 3 years after that state's implementation plan is approved by the United States Environmental Protection Agency.

[4] National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. Each state must attain the secondary standards within a "reasonable time" after implementation plan is approved by the United States Environmental Protection Agency.

Source: Montana Department of Environmental Quality.

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III.H LAND USES AND PLANS

The Golden Sunlight Mine is located in southwestern Montana, south of Bull Mountain in Jefferson County. The county is predominantly rural, with most of the land undeveloped or used as rangeland. The terrain is characterized by wooded mountains and intervening valleys of wet river bottoms and dry open ranges. Early land uses by Euro-American settlers were directly related to the extraction and utilization of natural resources, particularly placer gold mining. Through the late 1800s and early 1900s, hard rock mining became prevalent. This activity stimulated other land uses, including cattle grazing, food crops, small residential communities, transportation, timbering, mills, smelters, sawmills, and later, recreation in the form of hunting, fishing, and other outdoor activities (Jefferson County 1990).

Today the primary land uses in the vicinity of the proposed project are wildlife habitat, seasonal livestock grazing, and mineral extraction. In addition, agriculture (producing mainly feeder crops and livestock) is practiced in the valley areas of the Boulder and Jefferson Rivers and along Whitetail Creek (BLM 1990), and dispersed recreation occurs throughout the region. Tourism, Montana's leading growth industry, also is becoming more prevalent in the area.

The Deerlodge National Forest lies approximately 2 miles north of the mine. Interstate 90 (I-90) runs east-west 1 to 2 miles south of the mine. Highway 69 runs north-south 2 to 3 miles east of the mine. Water resources in the area include the Jefferson River to the south, the Boulder River to the east, and the Whitetail and Big Pipestone Creeks to the west (Forest Service 1990). The study area includes the small rural residential community of Cardwell and the active community of Whitehall, which provides for tourist accommodations and limited gaming. Several farms and ranches are located along the Jefferson River Valley south of the mine (BLM 1990). The nearest residence to the mine is located approximately 1 mile south of the West Waste Rock Dump (GSM 1995b).

III.H.1 Land Ownership/Jurisdiction

The proposed project lies within the BLM's Headwaters Resource Area, which extends along the east side of the Continental Divide in west-central Montana from the Blackfeet Indian Reservation near the Canadian border in the north to Yellowstone National Park at the Wyoming border in the south (BLM 1983). The Resource Area encompasses 9 counties totaling 13,067,420 acres, of which 311,337 acres (2.4 percent) are under BLM management. Jefferson County contains 97,499 acres of BLM-administered land, which comprises less than 10 percent of the county. A large portion of the county consists of National Forest Service land in the Deerlodge National Forest and Helena National Forest. The remaining lands are mostly privately-owned, with some interspersed sections of state-managed land.

The majority of surface land in the current and proposed permit area of the Golden Sunlight Mine is owned by GSM. The remaining surface lands consist primarily of BLM-administered tracts, with MDNRC-administered school trust land in Sections 16 (T2N, R3W) and 36 (T2N, R4W). Map I-2 shows surface land ownership in the project area. Table II-1 shows acreage and ownership of surface lands in the current mine permit boundary and disturbance area. The current permit area encompasses 5,071 acres, including 3,792 acres of GSM-owned land, 1,219 acres of BLM-administered land, and 60 acres of state school trust land. The current disturbance area encompasses approximately 2,336 acres, including 1,723 acres of GSM-owned land and 613 acres of BLM-administered land. No state surface lands are disturbed.

GSM either owns or leases subsurface lands (mineral estate) in the current and proposed permit area, including state school trust mineral estate. State school trust lands, both surface and mineral estate, are administered by the MDNRC, Trust Land Management Division. The lands are managed to benefit the state school trust. GSM must receive approval from MDNRC for activities on state trust lands, whether leased or unleased. The state school trust mineral estate in the project vicinity includes the following tracts:

T2N, R3W	Section 16	All of section
	Section 17	SE¼NE¼
		E½SE¼
		SW¼SE¼
	Section 20	SE¼
		W½NE¼
		NE¼SW¼
		Lot 1 (E½ of SE¼SW¼)
	Section 21	All of section
	Section 28	W½W½
	Section 33	NW¼
		Part of W½NE¼
		N½SW¼
		Part of S½SW¼
		Part of SE¼
T2N, R4W	Section 36	Lots 1, 2, and 3
		SW¼NE¼
		W½

Disturbance through currently permitted activities occurring above state school trust mineral estate is shown in Table II-2. A total of 357 acres of disturbance occurs above state school trust mineral estate, including 248 acres of sulfide-covered disturbance and 110 acres of non-sulfide covered disturbance.

III.H.2 County and Resource Area Plans

The Headwaters Resource Area Management Plan, approved by the BLM in 1983, is an issue-driven planning document. Objectives and policies for locatable minerals relate primarily to specific geographical areas and issues identified in the plan. Guidance for the management of locatable minerals throughout the Resource Area is provided by the statement that all public land is open to mineral entry and development unless previously withdrawn, but that mineral exploration and development on public land should be regulated to prevent unnecessary and undue degradation of the land (BLM 1983).

The Jefferson County Comprehensive Plan of 1993 recognizes several important land uses in the county, including mineral extraction, timbering, farming and ranching, transportation, and recreation and tourism. Mineral extraction, in particular, has played a key role in the history of the county, and formed the basis of the first economic activity of Euro-American settlers in the area. The county's current mining operations provide critical employment and economic benefits both for Jefferson County and neighboring communities and play an important role in the economic future of the area. The county recognizes that mining is a finite activity, however, and acknowledges the importance of expanding and diversifying the economic base. The Comprehensive Plan also emphasizes the value of "quality of life" issues and preserving environmental and cultural resources (Jefferson County 1993).

The Comprehensive Plan includes objectives that fall within three categories: economic, physical, and social/cultural. Specific goal statements with relevance to mining include the following:

- Stimulate the retention of existing and the development of new basic and value adding businesses and industries; especially agriculture, mining, timbering, and manufacturing/processing;
- Stabilize the County's tax base by encouraging the sustainable use of its natural resources and by working toward greater economic diversity;
- Invite continued mineral exploration, extraction and refinement; assuring that mining practices will be executed in a manner that will not adversely impact the value of surrounding properties and the usefulness of the County's other natural resources; and
- Preserve and promote Jefferson County's rich cultural heritage, rooted in natural resource development (Jefferson County 1993).

The Comprehensive Plan Map depicts the area around the mine as "Basic Resource with Development Constraints," which means that the land is to be protected for agriculture, timber, and mineral resource utilization, but may have development and use constraints including any of the following: public ownership, steep slope, flood susceptibility, poor access, lack of potable water supply, and/or fire suppression capability (Jefferson County 1990).

III.H.3 Transportation and Access

Major transportation routes in the area include I-90 and Montana State Highway 69. I-90 is the primary east-west highway in southern Montana and provides access from the project region to Bozeman and Billings to the east, and Butte and Missoula to the west; it passes approximately 1 to 2 miles south of the mine. Montana Highway 69 runs north-south and is located approximately 2 to 3 miles east of the mine. It connects with the town of Boulder and Interstate 15 (I-15) approximately 25 miles north of the mine. Montana Highways 55 and 41 run south from the Whitehall area to connect with the town of Dillon and I-15. Annual average daily traffic estimates for I-90 and Highway 69 are shown in Table III-7.

Access to the mine site is via Montana Highway 2, a frontage road paralleling I-90 and intersecting Montana Highway 69 east of the mine (GSM 1995b). The access road to the mine leaves Montana Highway 2 approximately 5 miles east of Whitehall and travels north for approximately 2 miles to the GSM plant site. Other haul and access roads lie within the mine site. Traffic along the Golden Sunlight Mine access road includes mine employees, vendors, contractors, and visitors. Mine-related vehicles within the project boundary include haul trucks, loaders, drilling equipment, pickup trucks, and maintenance trucks. An estimate of miles driven by traffic along the access and haul roads is provided in Table III-8.

Local access to the mine is restricted by fencing around the Golden Sunlight Mine permit boundary (GSM 1995b). Access to public lands north of the mine area is provided by a county road running from Whitehall along St. Paul's Gulch on the west side of Bull Mountain (Radford 1996). GSM compensates for the closure of public lands in the permit area by providing public access to privately owned land off of the mine site for recreation (see Section III.H.7, Recreation).

III.H.4 Rights-Of-Way

Several utility right-of-way exist in the project area. A natural gas pipeline runs along the southern edge of the mine permit boundary, parallel and 100 to 500 feet north of I-90. A main transmission line also parallels I-90, approximately 0.5 mile to the north. The transmission line connects to a Montana Power substation located along the mine access road within the mine permit boundary. A power line runs north from the substation along the mine access road to the main Golden Sunlight Mine processing facilities. This corridor also contains a natural gas pipeline and a telephone cable. A microwave power line intersects the Golden Sunlight Mine power line and curves east around the East Waste Rock Dump to connect to a microwave tower a few hundred feet north of the mine permit boundary.

III.H.5 Grazing

Cattle grazing occurs on federal, state, and private lands in the project area. Portions of two large grazing allotments are located within the Golden Sunlight Mine permit boundary (McNee 1996). The Bull Mountain Allotment is located northwest of the mine and within the northwest corner of the mine permit boundary. It encompasses approximately 5,410 acres (5,250 acres of BLM-administered land and 160 acres of isolated parcels of GSM patented mining claims). Approximately 685 acres occur within the Golden Sunlight Mine permit boundary, and approximately 205 acres lie within the current disturbed area of the mine. The federal land areas of the allotment have a preferred stocking rate of 652 animal unit months (AUMs), or 8.05 acres per AUM, and are grazed under three separate leases. The land is divided into four pastures, grazed on a three-pasture rest rotation system in which one pasture is deferred from grazing for one or more years. The terrain is very rugged and the grazing quality is fair to good, with some knapweed and leafy spurge problems on the western edge, which the BLM sprays annually to

Table III-7

1994 Annual Average Daily Traffic on Interstate 90 and Highway 69

Location	Number of Vehicles
Interstate 90	5,840
West of Whitehall	
East of Whitehall	5,400
Highway 69	
North of Intersection with I-90	600

Source: Lythgoe 1995 (Montana Department of Transportation).

Table III-8

Traffic Along GSM Haul and Access Roads

Vehicle Types	Access Road	Haul Road
Employee Personal Vehicles	560 miles/day	NA
Vendor and Tourist Vehicles	140 miles/day	NA
Delivery Trucks	64 miles/day	2,190 miles/year
Mine Haul Trucks	NA	813,000 miles/year
Drilling and Maintenance Vehicles	20 miles/day	428,000 miles/year
Total	784 miles/day	1,243,190 miles/year

Source: GSM 1995b.

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control. In 1991, upland vegetation conditions were noted to be improving slowly, after a period of overgrazing in some areas (McNee 1996).

The Hill and Wilkerson Allotment encompasses an area northeast of the mine (adjacent to the Bull Mountain Allotment) and partially within the northeast section of the mine permit boundary (McNee 1996). It measures approximately 4,200 acres and is comprised primarily of private land. A section of state school trust land and two BLM-administered parcels are included in the allotment. Approximately 1,415 acres of the allotment lie within the current mine permit boundary, and approximately 460 acres lie within the current disturbed area. The stocking rate for most of the allotment is determined by the private property owners and lease-holders. Public agencies have determined stocking rates for the public land sections within the allotment. A 60-acre portion of the state school trust section that lies within the existing mine permit boundary has an estimated stocking rate of 18 AUMs (3.3 acres per AUM) (Seybert 1997). A 70-acre BLM-administered parcel that lies within the existing mine permit boundary has a preferred stocking rate of 10 AUMs (7 acres per AUM). Ten acres of this grazing tract (formerly an 80-acre tract) have been lost to previous mining activities. Range quality is considered fair to good (McNee 1996).

Over 1,700 acres within the existing Golden Sunlight Mine permit boundary are currently used for grazing, including portions of the two allotments described above (Seybert 1996). The majority of this land lies on the east side of the mine property, within the Hill and Wilkerson Allotment. Approximately 400 cattle, belonging to one lease holder and property owner, graze on privately owned tracts, GSM tracts, and public tracts within the allotment. The cattle graze on land within the Golden Sunlight Mine permit boundary for approximately 3 to 5 weeks in the spring before being moved to other grazing lands north of the mine. The undisturbed area to the south of the mine, within the existing permit boundary, is not leased for grazing and is maintained for wildlife purposes. Second-cuttings of alfalfa hay, on agricultural land located below the tailings impoundments, are left standing for fall and winter mule deer and antelope forage (Seybert 1996).

Areas of state and federal land located south of the mine permit boundary in Sections 31 and 36 also are utilized for grazing. Grazing on state school trust land in Section 36 is managed through two leases: one encompassing 120 acres with 10 AUMs allotted (12 acres per AUM), and one encompassing 323 acres with 54 AUMs allotted (6.0 acres per AUM) (Seybert 1997). The 138-acre parcel of BLM land in Section 31 has a preferred stocking rate of 12 AUMs (11.5 acres per AUM) for grazing horses (McNee 1997).

Range improvements on the east side of the mine property within the Hill and Wilkerson Allotment include a system of water troughs and pipelines from the Sheep Rock Spring, built and maintained by GSM. Range improvements in the Bull Mountain Allotment include an extensive water pipeline connecting the Tebay Spring, north of the allotment, with water troughs to the south. This system is being displaced by currently permitted activities at the mine. GSM will either reroute the pipeline around the West Waste Rock Dump or develop an existing well to the southeast. Range improvements are utilized by both cattle and wildlife. Other springs in the area also have been developed. A water development south of Tailings Impoundment No. 2 is maintained by GSM year-round for wildlife (Seybert 1996; McNee 1996; GSM 1995b).

III.H.6 Recreation

Dispersed backcountry recreation is the predominant type of outdoor recreation in the Headwaters Resource Area and in Jefferson County (Rixford 1996). The main recreational activities include hunting, fishing, floating, horseback riding, hiking, camping, off-highway vehicle use, snowmobiling, and cross-country skiing. A few campgrounds exist in the region, associated with either BLM-administered land, the National Forest Service, or the MDFWP. The Deerlodge National Forest, offers dispersed recreational activities, including several maintained trails (Forest Service 1995). Access to the National Forest is primarily through areas several miles west and north of the mine. The Lewis and Clark Caverns State Park, located approximately 7 miles south of the mine, attracts tourists to the area and offers activities such as guided tours, camping, hiking, and concessions (MDFWP 1995).

No significant recreation developments occur in the vicinity of the Golden Sunlight Mine and dispersed recreational use is very light. A county road running north of Whitehall, along St. Paul Gulch west of the mine provides access for hunting. Most of the land around the mine is privately owned, however, and public recreation opportunities are limited. Deerlodge National Forest lands immediately north of the mine are designated with travel restrictions; road vehicles, trail bikes, and all-terrain vehicles are restricted from most roads and trails all year long (Forest Service 1990). The primary attraction in the valley is the Jefferson River for fishing, floating, wildlife observation, picnicking, and some waterfowl hunting. Most recreationists are local residents (Rixford 1996).

Hunting opportunities in the region consist mainly of mule deer, white-tailed deer, elk, pronghorn, and upland game birds (Rixford 1996). Hunting quality is fair. Statistics for the 1994 season show that in the deer hunting district where the mine is located, 540 hunters were granted permits and 217 animals were harvested. For the elk district, 560 hunters were granted permits and 105 animals were harvested. For pronghorn, the mine area falls within two hunting districts. In one district, 84 hunters were granted permits and 55 animals were harvested; in the other district, 105 hunters were granted permits and 71 animals were harvested (Carlsen 1996).

Other recreational opportunities exist on GSM-owned and maintained properties in the area. Although, privately-owned, they are maintained open to the public for hunting, fishing, and other recreational opportunities. In an area dominated by private property with restricted access, these properties constitute important resources for public recreation. The Candlestick Ranch, located 4 miles east of the mine, was purchased by GSM to preserve as open space and wildlife habitat. The property encompasses 3,200 acres and includes a privately operated ranch; an additional 1,900 acres are leased from the BLM and the state of Montana. The Boulder River runs through the property. Ninety percent of the land is managed for wildlife, wetlands and riparian protection, and streambank restoration. The remaining 10 percent is utilized for hay cultivation and grazing. Wildlife on the property includes white-tailed deer; elk; mule deer; and upland game birds, including pheasants. Recently, wild turkeys also were introduced. Law enforcement on the property is provided by the MDFWP.

In 1991 GSM purchased 500 acres in the Piedmont Swamp, an open water and cattail area, located 1.5 miles southwest of Whitehall. GSM's aim in purchasing the land was to consolidate the properties and protect this significant wetland for waterfowl and wildlife habitat. GSM is currently working with the USFWS, MDFWP, BLM, Ducks Unlimited, and others in order to restore and enhance the swamp and develop recreational and educational opportunities for the public. Another GSM-owned property is located 5 miles north of the mine on the eastern front of Bull Mountain. This 640-acre parcel provides critical winter range and calving areas for elk and mule deer. Other species include pronghorn and upland birds. The property adjoins Forest Service land and contains a year-round stream. Law enforcement is provided by the MDFWP. Open public access is maintained on all of these properties.

III.I AESTHETIC RESOURCES

III.I.1 Visual Resources

The objectives of the visual analysis are to identify and describe the visual resources that could be affected by the construction and operation of the Proposed Action. Visual quality is an important resource for its value in relation to potential viewers and their use or enjoyment of an area, particularly in sensitive use areas or areas with high natural scenic value and unique or unusual features. The study area includes landscapes in which viewers may travel, recreate, or reside where views may potentially be affected by the Proposed Action.

III.I.1.a Visual Resource Management

The BLM Visual Resource Management (VRM) system is designed to help manage the quality of the landscape by minimizing impacts to visual resources resulting from development activities, while maintaining the effectiveness of all BLM resource programs. Through the visual analysis process outlined in BLM Handbook 8410-1, *Visual Resource Inventory*, rating categories are assigned describing the relative value of the visual resources and the associated management objectives (BLM 1986a). The first step is the Visual Resource Inventory (VRI), which analyzes three components - scenic quality, viewer sensitivity, and distance zone - to provide an assessment of the current visual resources. VRM Classes I to IV are then assigned for the area, with management objectives ranging from maintaining minimal visual disturbance to allowing activities that entail major landscape modifications. Management objectives for each class are described in Table III-9.

The BLM, to date, has not assigned a VRM Classification for the lands around the Golden Sunlight Mine, although the area has generally been managed as a potential VRM Class IV area because of the existing mining disturbances. Under this classification, any changes to the characteristic landscape can be high and activities may dominate the view and be the major focus of viewer attention. As part of the visual resource analysis for this EIS, a VRI was conducted to assess current visual values and assign a suggested interim VRM Classification. The VRI was based on field reconnaissance conducted during October 1995, and photographs taken from several key observation points (KOPs), including transportation corridors and residential and recreation areas.

The results of the VRI yielded a Class III rating. Data and results of the VRI are provided in Appendix F. The study area was defined as the ridgeline encompassing present mining activity and surrounding BLM lands and parts of the surrounding valleys. Scenic quality was rated as Class B, with moderate scenic value; viewer sensitivity was rated as moderate; and the distance zone was defined as foreground-middleground. A Class III rating provides for moderate changes to the existing landscape and activities that may attract the attention but not dominate the view of the casual observer. Under a Class III rating, areas which currently do not conform to the management objectives would be designated as "Rehabilitation Areas"; these areas would be rehabilitated upon project completion to restore the natural characteristics of the landscape to the extent required for a Class III visual resource rating.

III.I.1.b Landscape Characteristics

The Proposed Action lies within the Northern Rocky Mountain physiographic province in southwestern Montana. The terrain is characterized by wooded mountains and intervening valleys of wet river bottoms and dry open ranges. The existing mine is located at the southern tip of a north-south trending ridge, which comprises the southern flank of Bull Mountain. Elevations in the project area range from 6,000 to 6,500 feet. The ridgeline is a prominent feature, surrounded on the west, south, and east sides by broad, flat valleys. The Jefferson Slough and Jefferson River run east-west through the valley south of the ridge. The Boulder River runs north-south through the valley east of the ridge. Several other creeks and drainages are interspersed in the hills and valleys in the area.

Table III-9

BLM Visual Resource Management Classes

Class	Description
I	The objective of this class is to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.
II	The objective of this class is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.
III	The objective of this class is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.
IV	The objective of this class is to provide for management activities, which require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high. These management activities may dominate the view and be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements.

Source: BLM 1986a.

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The area contains varied vegetation. Hills and slopes are vegetated with limber pine and juniper forest intermixed with grassland and Douglas-fir forest in the higher elevations. The valleys contain grasslands intermixed with sage and other shrubs, with a few interspersed limber pine and juniper. The color of the hillsides includes patches of dark green intermixed with the dull tans and golds of the grasses. The valleys are mostly shades of tan and gold, with shrubs providing a contrast of deeper golds, reddish-orange, and sage green, interspersed with dots and patches of the dark green limber pine and juniper.

Visual disturbances from the existing Golden Sunlight Mine are visible on a portion of the ridge. Large sections of the waste rock piles are clearly visible from the west and east, and the pit highwall and portions of the pit benches are visible from the east. These features are unvegetated and contain bright shades of white, tan, yellow, and gray that contrast with the duller colors of the vegetated, natural landscape. The sharp horizontal and vertical lines, and geometric forms of mine features contrast with the soft features, rolling lines, and diffuse and rounded forms of the natural landscape. These existing impacts dominate in views toward the mine site, and are not consistent with Class III VRM objectives.

The ridge line is clearly visible from within 5 miles, and remains a prominent visual feature from within 15 miles, as viewed from two main travel routes through the area. I-90, running east-west, passes 1 to 2 miles south of the mine site; it is the major east-west thoroughfare of southern Montana. State Highway 69, running north-south, passes 2 to 3 miles east of the mine site. The towns of Whitehall and Cardwell are each located within the 5-mile viewshed of the project. The primary viewers include travelers on the two roadways, local residents, and workers at the mine. As discussed is Section III.H.7, Recreation, light recreation use occurs in the area in the form of dispersed activities such as hunting, hiking, and fishing along the Jefferson and Boulder Rivers; most users are local residents. No significant developed recreation resources or designated sensitive areas or wilderness areas exist within the viewshed of the proposed project.

III.I.2 Noise

Current noise conditions in and around the Golden Sunlight Mine site are dominated by noise from highway and road traffic and current mining activities. Very few sensitive noise receptors exist near the mine. The nearest residences located outside the permit boundary are 2 private residences, located approximately 1 and 1.2 miles to the south of the West Waste Rock Dump (GSM 1995b). Other sensitive noise receptors include 2 residences located within 2 miles, 3 residences within 3 miles, and 3 residences located within 4 miles of the waste rock dump facilities. Because of the mine's proximity to I-90, which runs along the south side of the mine project boundary, the nearest receptors are subjected to significant traffic noise. Highway and road noise dominate the noise environment at many of these sensitive receptors. All activities at Golden Sunlight Mine are subject to noise regulations and guidelines imposed by the MSHA.

Noise, as perceived by humans, is affected by intensity, pitch, and duration (GSM 1995b). "Loudness" is measured in decibels (dB). The A-weighted system (dBA) of measuring sound levels is used because it more closely emulates human hearing, which is more sensitive to high frequency (high pitch) sounds. For baseline comparisons, Table III-10 shows typical public reactions to various noise levels, and equivalent everyday indoor and outdoor activities that would generate these noise levels. Table III-11 shows noise levels for typical mining activities, as determined by researchers in previous noise studies. As indicated in the table, most noise generated by mining activities ranges from 85 to 95 dBA close to the source. Blasting generates the highest levels of noise (115 to 125 dBA at 900 feet). Simultaneous mining activities would produce noise louder than any of the single activities, when measured alone. In addition, weather conditions can influence noise transmission. Sound waves travel more efficiently through cold air than warm air, and thus, mining noise may be more audible during periods of cold weather (GSM 1995b).

Table III-10

Relative Scale of Various Noise Sources and Effect on People

Noise Level (dBA)	Common Public Reaction	Equivalent Indoor Activities	Equivalent Outdoor Activities
5		Threshold of hearing	
15		Broadcast and recording studio	
25		Concert hall (background)	Quiet rural nighttime
28		Bedroom at night	
33		Library	
35			Quiet suburban nighttime
40		Small theater, Large conference room	Quiet urban nighttime
50	Acceptance	Dishwasher in next room	Quiet urban daytime
60	Complaints rare	Large business office	
65		Normal speech at 3 ft.	Commercial area, heavy traffic at 300 ft.
70	Complaints possible	Vacuum cleaner at 10 ft.	Gas lawn mower at 100 ft.
80	Complaints likely	Garbage disposal at 3 ft., Shouting at 3 ft.	Noisy urban daytime
90	Letters of protest	Food blender at 3 ft.	
95			Gas lawn mower at 3 ft.
100	Local community activity with influential or legal action	Inside New York subway train	
105			Jet flyover at 1,000 ft.
110		Rock band	

Source: GSM 1995b.

Table III-11

Average Sound Levels for Equipment and Mine Operations

Equipment/Operations	Noise Levels (dBA)	Source of Information
Bulldozers	85 dBA at 50 feet	U.S. Bureau of Mines and Geology 1976
Blasthole Drilling	86 dBA at 50 feet	CMC Inc. 1989
Loaders	87 dBA at 50 feet	EPA 1978
Haul trucks	90 dBA at 50 feet	Reagan and Grant 1977
Crusher	95 dBA at source	Reagan and Grant 1977
Blasting	115 to 125 dBA at 900 feet	Reagan and Grant 1977

Source: GSM 1995b.

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On August 14, 1995, GSM conducted a survey during mine operations, including both blasting periods and normal operations, to measure noise levels at various receptor points. Readings were taken at 24 sites, including all nearby residences and several road crossings, bridges, hills, and other prominent or frequented locations. Data were collected using a calibrated Quest Technologies, Micro-15 noise dosimeter. Measurements were taken between the hours of 10:00 a.m. and 1:00 p.m. Sky conditions were clear with winds from the south-southwest at 0 to 5 mph (GSM 1995b). Measurements were recorded in the form of "spot" readings or peak measurements taken over a very short period.

Background noise at all of the sites yielded measurements of 50 to 51 dBA (GSM 1995b). This noise included sound from roadways and mining activity. Maximum measurements were recorded when traffic passed by on the highway. These readings, recorded at 9 sites, ranged from 55 to 88 dBA, and averaged 73 dBA. Mining activity noise includes dumping in the waste rock areas, bulldozing, loading, crushing, drilling, hauling, and blasting. Noise measurements at the receptor sites appeared to be dominated by highway noise. Blasting is a routine, controlled event at the Golden Sunlight Mine, occurring once per day at approximately 1:00 p.m. Blasting events were included in readings at 3 of the sites in the survey (at locations approximately 2 and 2.7 miles from the pit). These events yielded no change in the peak background noise readings (Dorvall 1996). Most noise from blasting is shielded from sensitive receptors by the topography. In addition, blasting creates predominantly low frequency noise, which is weighted lower in the dBA measurement system.

Other noise from the mine is generated by hazing devices used to keep birds and other wildlife away from the tailings impoundment areas. A system of 16 propane cannons fires at approximately 15-second intervals. Another device emits electronic sounds at different frequencies and durations; it recently replaced an old system of playing amplified rock music. The electronic sounds (or music) are not in use during the cold season when the water on the ponds is frozen. Past noise disturbances to nearby residences caused by the propane cannons have been addressed by repositioning the devices below embankments and orienting them toward the north (away from residences). Propane cannon firings were included in background noise readings at the survey sites; no significant changes were measured (Dorvall 1996).

III.J SOCIAL AND ECONOMIC RESOURCES

III.J.1 Population

The Golden Sunlight Mine is located in Jefferson County, Montana. The county consists of three main population and economic centers: the Helena area in the north, Boulder in the central part of the county, and the I-90 corridor in the south. The Golden Sunlight Mine influences primarily the area along the I-90 corridor, including communities in adjacent Silver Bow County. Most GSM employees live in the communities of Whitehall, Butte, and Cardwell.

Population figures for the area are shown in Table III-12. The state of Montana had a 1995 population of 870,300, an increase of 8.9 percent since 1990. Jefferson County had a 1995 population of 9,200, an increase of 15.9 percent since 1990. The town of Whitehall, approximately 5 miles southwest of the mine in Jefferson County, had an estimated 1995 population of 1,200, an increase of 12.5 percent since 1990. The city of Butte, approximately 30 miles west of the mine in Silver Bow County, had a 1995 population of 34,800, an increase of 2.5 percent since 1990. The town of Cardwell, approximately 2 miles southeast of the mine in Jefferson County, is a very small town with a semi-rural character. Its 1995 population was estimated at less than 100 (Sylvester 1996).

III.J.2 Economy, Employment, and Income

Jefferson County is a rural county, with a culture and economy historically dependent upon the land itself. Early economic activities were directly related to the extraction and utilization of natural resources. The mineral wealth found in the mountains and valleys of western Montana stimulated the county's initial growth. Other activities such as timbering, grazing, and agriculture followed. Natural resource activities continue to dominate the economy and culture (Jefferson County 1993).

A comparison of several counties in southwestern Montana from 1970 through 1990 shows that counties with large urban centers had large fluctuations in total employment, while more rural counties experienced very little change. The sole exception was Jefferson County, which had a major increase in employment from 1983 to 1989. This increase is due to a combination of rapid suburban migration from Helena and job growth associated with the opening of two major mining operations: Montana Tunnels and Golden Sunlight Mine (Jefferson County 1993). Table III-13 shows current employment information for Jefferson County and the state of Montana. The 1994 labor force for Jefferson County was 4,349, with an unemployment rate of 3.7 percent, compared to the state's 5.1 percent (Sylvester 1996).

Employment by sector information (see Table III-13) shows that total covered employment for Jefferson County in 1994 numbered 2,143. This is roughly half of the number counted employed in labor force information. The disparity is explained by the fact that labor force estimates are determined by the place of residence and covered employment is determined by the place of employment. Many people living in Jefferson County are employed in Helena and Butte, located in neighboring counties; Jefferson County serves as a kind of rural and semi-rural residential suburb for these communities. In addition, covered employment counts only those workers covered by unemployment insurance. Because of the agrarian nature of the county, many self-employed individuals are not counted (Sylvester 1996; Jefferson County 1993).

The largest sectors of employment in Jefferson County in 1994 were government, with 37.5 percent of covered employment, and mining, with 24.4 percent. The government sector is relatively large because a state school for the developmentally disabled, the Montana Development Center, is located in the county. It is important to note that employment sector information does not count the large number of individuals self-employed in agriculture, which is probably a significant form of employment in the county. Montana state employment is concentrated in services (26.7 percent), retail

Table III-12

Population

	1990	1996	Percent Increase
Montana	799,065	870,300	8.9
Jefferson County	7,939	9,200	15.9
Whitehall	1,067	1,200	12.5
Butte	33,941	34,800	2.5
Cardwell	<100	<100	--

Source: Sylvester 1996

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Table III-13

Employment and Income

	Jefferson County			Montana		
Labor Force (1994)	4,349			437,000		
Unemployment Rate (1994)	3.7%			5.1%		
Per Capita Income (1993)	$18,087			$17,376		
Total Personal Income (1993)	$155,503,000			$14,812,476,000		
Employment Sector (1994)	Number Employed	Percent of Employment	Average Annual Wage	Number Employed	Percent of Employment	Average Annual Wage
Agriculture/Forestry/Fisheries	35	1.6	$13,354	3,996	1.2	$15,057
Mining	522	24.3	41,694	5,451	1.7	38,974
Construction	93	4.3	21,186	14,984	4.6	24,387
Manufacturing	125	5.8	32,952	23,004	7.0	25,651
TCPU[1]	78	3.6	25,510	17,502	5.3	28,294
Wholesale Trade	31	1.4	21,515	17,574	5.4	25,082
Retail Trade	265	12.4	7,113	74,879	22.8	12,032
FIRE[2]	36	1.7	13,760	15,170	4.6	23,788
Services	147	6.9	11,451	87,715	26.7	17,885
Government	804	37.5	20,282	67,905	20.7	24,180
Total, All Industries	2,143	100.0	$23,978	328,218	100.0	$20,222

[1] Transportation, Communication, and Public Utilities.

[2] Finance, Insurance, and Real Estate.

Source: Sylvester 1996, for all data except Average Annual Wage (Source: Shenkle 1996).

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trade (22.8 percent), and government (20.7 percent) (Sylvester 1995).

Between 1980 and 1990, Jefferson County experienced large increases in the sectors of mining, construction, manufacturing, and retail trade. This growth is largely attributable to the opening of the two major mining operations (Jefferson County 1990). Mining provides significant contributions to employment in Jefferson County. GSM provided 257 jobs in 1994, accounting for nearly half of the mining employment in Jefferson County and approximately 12 percent of total covered employment. In 1995, GSM employment averaged 301 personnel. Due to recent layoffs at Golden Sunlight Mine, occurring in August of 1996, current employment numbers 205. The town of Whitehall, in particular, is dependent on the mine. Of the mine's 277 full-time workers employed in early 1995, 158 (57 percent) were noted to reside in Whitehall (GSM 1995b). Counting family members of employees, this constituted an estimated 40 percent of the town's population dependent on employment at the mine. Secondary employment, primarily in the services sector, also is supported in the community by mining jobs at Golden Sunlight Mine. The mine and related activities provide an important base for the economy in the Whitehall area.

Mining employment is significant also because of the high wages paid in the industry. Table III-13 shows income data for Jefferson County and the state of Montana. In 1993, Jefferson County had a per capita income of $18,067 compared to the state's $17,376. Average annual wages in the county were $23,976 for 1994 in all industries, compared to the state's $20,222. Wages and income are higher in Jefferson County largely because a higher proportion of jobs in the county are in the mining sector. As shown in the table, mining sector jobs earn the highest average annual wages of any employment sector, by a wide margin. The average annual wage in the mining sector for Jefferson County is $41,694. Total personal income in the county in 1993 was $155,503,000. The portion representing wages and salaries is estimated at $52,560,000. Gross payroll at Golden Sunlight Mine in 1993 was $11,259,255, or approximately 21 percent of the wages and salaries for the county.

III.J.3 Community Services

Data for community services and infrastructure were analyzed primarily for the town of Whitehall, because it experiences the greatest influence from the mine. Of the mine's 277 employees employed in early 1995, 57 percent (158) lived in Whitehall, 24.9 percent (69) lived in Butte, 4.7 percent (13) lived in Cardwell, and 13.4 percent (37) lived in other locations (GSM 1995b). Current employee residence patterns are expected to be similar. Butte has a large population compared to its number of resident GSM employees, so the impact on its services and infrastructure is relatively minor. Cardwell is an unincorporated, semi-rural town with very little community infrastructure. Other towns in the area have only small concentrations of GSM employees.

According to census data, the 1990 housing stock in Jefferson County consisted of 3,302 units, of which 1,240 were specified as owner-occupied and 514 renter-occupied. The median mortgage payment was $595 and the median rent was $299. In Whitehall, there were 502 housing units, 239 of which were specified as owner-occupied, and 138 as renter-occupied. The median mortgage payment in Whitehall was $519. The figure for median rent was not available (U.S. Department of Commerce 1990). Housing prices have been rising steadily in Whitehall for the past 4 to 5 years and continue to rise slowly, although they appear to be reaching a plateau. Housing supplies are considered adequate for current demand. A number of units are on the market at any one time, and homes normally sell within 4 to 6 months. No subdivision housing is currently planned for the region, and few economic incentives exist for development of this type. Building occurs mainly in the form of single homes around the outside of town. However, rental housing is relatively scarce, and excess demand exists for these type of units. Available units usually rent within 2 weeks (Gallagher 1996).

The water supply in Whitehall comes from groundwater sources. Excess capacity exists for 40 to 50 percent growth over the existing service volume. Wastewater treatment was upgraded in 1980. Capacity is still available in this system. Solid waste is disposed of in a county landfill through a transfer station north of town. Services are currently considered adequate. Law enforcement and fire protection also are adequate for Whitehall. The town is served by a full-time Marshall, a part-time deputy, and a fire Marshall. The fire truck is currently being upgraded. Health care is provided by a volunteer ambulance and a clinic in Whitehall. Services are adequate. Community recreation facilities consist of parks, ball fields, a pool, rodeo, and a senior center. These facilities are adequate for the population (Gallagher 1996).

School capacities and enrollments are shown in Table III-14. The mine presently impacts the populations of primarily two school districts: Whitehall (containing an elementary, middle school, and high school), and Cardwell (containing one elementary). In early 1996 it was estimated that 15 to 20 percent of all students in these schools had parents employed by the mine. The current percentage may be somewhat less due to recent layoffs at the mine. All schools are currently under capacity, with steady upward trends in enrollment. The high school can accommodate approximately 65 more students. The middle school can accommodate approximately 27 more students. Cardwell Elementary, an old school built in 1904 and expanded in 1918, is at less than 50 percent capacity and can accommodate approximately 63 more students. The elementary school in Whitehall is the closest to full capacity, with room for only 10 to 30 more students. No plans currently exist for expansion or construction of new school buildings. The recently constructed middle school opened in January 1995 (Berenger 1996; Veca 1996).

The Golden Sunlight Mine currently provides substantial portions of the funding for schools in these two districts. The Hard-Rock Mine Trust Reserve Account was established several years ago to assist with funding constraints when the mine closes. Two-thirds of the fund are allocated for affected school districts (one-third for elementary schools and one-third for high schools). Details of the fund are provided in Section III.J.5, Hard Rock Mine Trust Reserve Account.

III.J.4 Public Finance

Over two-thirds of state revenues are derived from taxes. The largest single source of revenue for the state is income tax, which provided one quarter of total revenue in 1992. Montana does not have a comprehensive sales tax, but it does have selective sales taxes on such items as motor fuels and gas, alcohol, tobacco, and insurance premiums; selective sales taxes provided 13.3 percent of state revenue in 1992. The property tax, which includes the gross proceeds tax, provided 12 percent of revenue. The severance tax on mineral production (coal, oil, gas, and metal mines), which includes the metals mine license tax, provided 8.1 percent of total revenue. Other tax revenues, including professional and business licenses, the inheritance tax, and payroll tax provided 9.7 percent of total revenue. Non-tax revenue provided approximately one-third of total state revenue in 1992 (Finch 1996).

Jefferson County revenues and expenditures are shown in Table III-15. Total revenue exceeded expenditures in the county in 3 out of the 5 years between 1991 and 1995. Budget deficits occurred in the fiscal years of 1993 and 1995. Taxes provided an average of 50 percent of total revenue for the county in the 5 years from 1991 to 1995. County tax revenues are confined primarily to the property tax, because there is no sales tax and no local-option income tax. Property tax is assessed based on the total taxable value for the county (shown in Table III-16), and the consolidated mill levy. The taxable value for the county totaled $25,207,818 in 1995. Taxable value has fluctuated since 1990, but has shown an overall growth trend. Total taxable value increased 13.6 percent from 1990 to 1995 and had an average annual increase of 2.7 percent. Most of the property tax collected is allocated to schools (75 percent), with the exception of county general and road funds (25 percent). In 1995,

Table III-14

School Capacities and Enrollments

School	Current Capacity	Enrollment			
		1995-96	1994-95	1993-94	1992-93
Whitehall District[1]					
Elementary	300-320	289	255	269	253
Middle School	180	153	142	150	144
High School	250	185	180	167	165
Cardwell District[2]					
Elementary	100	37	45	47	55

[1] Source: Berenger 1996.

[2] Source: Veca 1996.

Table III-15

Jefferson County Revenues and Expenditures

	1995	1994	1993	1992	1991
Total Revenues	**$3,789,873**	**$3,632,588**	**$3,202,594**	**$4,625,746**	**$3,620,913**
Taxes	1,929,409	1,888,020	1,676,879	2,894,114	1,169,336
Taxes, % of Revenues	50.9%	52.0%	52.4%	62.6%	32.3%
Other Revenues	1,860,464	1,744,568	1,525,715	1,731,632	2,451,577
Total Expenditures	**$4,243,725**	**$3,612,128**	**$3,221,719**	**$3,022,589**	**$2,843,269**
Balance	**-$453,852**	**$20,460**	**-$19,125**	**$1,603,157**	**$777,644**

Source: Miller 1996.

Table III-16

Jefferson County Total Taxable Value

	1995	1994	1993	1992	1991
Total Taxable Value	$25,207,818	$25,845,850	$24,361,661	$23,337,140	$24,029,493
Increase from Previous Year	-2.5%	6.1%	4.4%	-2.9%	8.3%
Average Annual Increase, 1990 to 1995: 2.7%					

Source: Miller 1996.

county general and road funds (25 percent). In 1995, the consolidated mill levy for the taxing district of the Golden Sunlight Mine was 244.04 mills (Miller 1996).

Mining contributes significantly to state and county revenues. Two taxes specific to the mining industry are the metals mine license tax and the gross proceeds tax. Both are tied to the value of mining production. The metals mine license tax is a state tax. The gross proceeds tax is a property tax, levied at the county level. Since it began production in 1982, GSM has made economic contributions to the state, county, and local communities in the form of the metals mine license tax, the gross proceeds tax, and other taxes and economic benefits. Table III-17 shows economic contributions made in the 5 years from 1991 to 1995. GSM provides a significant portion of the property taxes collected in the county. Property tax revenues comprise the majority of the funding for schools and the county general fund. Golden Sunlight Mine's taxing district includes Whitehall High School and Cardwell Elementary. Table III-18 shows GSM's contributions to property tax funding for the county general fund, Cardwell Elementary, and Whitehall High School in 1994 and 1995. In 1995, GSM provided 13.1 percent of the property tax funding for the county general fund, 77.2 percent for Cardwell Elementary, and 39.3 percent for Whitehall High School. The percentage contributions were 4 to 8 percent higher in 1994.

III.J.5 Hard-Rock Mine Trust Reserve Account

In 1986, the state of Montana established the Hard-Rock Mining Impact Trust Account to address the "boom and bust" impacts of large-scale mineral development. The trust is designed to provide financial assistance for communities affected by workforce reductions or closure of hard rock mining operations. From 1986 to 1989, the state allocated 33 percent of the metals mine license tax collected to the fund. In 1990, funds were transferred to the county administrations where the mines are located. Since 1990, 25 percent of each year's state metal mines license tax has been distributed to the respective counties of the taxpaying mines for allocation to the trust reserve account. In 1995, the trust reserve account in Jefferson County held $3,603,414, which will be distributed between three districts containing operations that have paid into the fund: the Golden Sunlight Mine, Montana Tunnels, and Basin Creek (Miller 1996).

The trust account funds for a district become available in the event that either a mining operation permanently ceases all mining-related activity or its full-time workforce is reduced to less than one-half of the average of the immediately preceding 5-year period. Distribution of the funds at this time will be one-third to each of the affected elementary and high school districts and the remaining third to the county. The county may use the funds for such purposes as paying for outstanding capital project bonds, decreasing property tax mill levies specifically related to mine closure or reduction in operations, promoting diversification and development of the economic base, attracting new industry, providing cash incentives for expanding the employment base, or providing grants or loans to other local government jurisdictions affected.

A portion of the funds also are available to the county on an on-going basis for economic development activities. Jefferson County has used these funds to establish an Economic Development Task Force, with authority to recommend policies and projects for the county. The Task Force consists of 10 members, representing local business associations, the mining industry, the financial industry, state and local governments, and private citizens. Their mission is to improve employment opportunities in the county by identifying needs and priorities, and strengthening and coordinating economic development activities. The focus of the Task Force is on strategies to utilize private and government resources and the development of programs to encourage the growth of business in the county (Bartlett 1996).

The Task Force was established in January 1995 and will be reviewed by the County

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Table III-17

Economic Contributions of Golden Sunlight Mine

	1991	1992	1993	1994	1995
Troy Ounces of Gold Produced	80,000	100,900	121,618	50,097	89,799
Number of Employees	269	266	263	257	301
Payroll:					
Gross Payroll	$10,232,000	$10,631,320	$11,259,255	$11,489,970	$11,997,456
Payroll Taxes	864,400	881,416	965,738	955,777	967,801
Workman's Compensation	197,000	327,403	245,887	320,871	192,790
Employee Benefits	1,481,394	1,504,225	1,684,612	1,807,213	1,999,579
Total Payroll:	**$12,774,794**	**$13,344,364**	**$14,155,492**	**$14,573,831**	**$15,157,626**
Taxes Paid:					
Property Taxes	$614,164	$503,267	$490,757	$637,211	$672,092
Gross Proceeds Tax	279,379	215,834	213,728	295,376	238,730
Metals Mine License Tax	638,385	490,302	614,056	702,719	318,557
Total Taxes:	**$1,531,928**	**$1,209,403**	**$1,318,541**	**$1,635,306**	**$1,229,379**
Purchases of Goods and Services:					
In Montana	$20,780,972	$21,989,455	$17,425,082	$13,576,014	$21,078,008
Outside Montana	8,604,606	9,040,229	13,090,638	12,193,085	13,929,156
Total Purchases:	**$29,385,578**	**$31,029,684**	**$30,515,720**	**$25,769,099**	**$35,007,164**
Employee Taxes:					
Employee's Withholding for Federal Taxes	$1,313,100	$1,320,647	$1,473,100	$1,542,317	$1,546,750
Employee's Withholding for State Taxes	459,100	501,266	526,642	531,643	567,049
Employee's Withholding for FICA	778,600	809,233	856,585	874,231	914,954
Total Employee Withholding:	**$2,550,800**	**$2,631,146**	**$2,856,327**	**$2,948,191**	**$3,028,753**

Source: Bartlett 1996.

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Table III-18

GSM Contribution to County and School District Property Tax Revenues

	1994	1995
County General Fund:		
Total Funds from Property Tax	$110,177	$163,360
GSM Contribution	$18,917	$21,405
GSM Percent of Total	17.2%	13.1%
Cardwell Elementary:		
Total Funds from Property Tax	$60,925	$43,687
GSM Contribution	$49,626	$33,729
GSM Percent of Total	81.5%	77.2%
Whitehall High School:		
Total Funds from Property Tax	$216,576	$329,161
GSM Contribution	$102,094	$129,394
GSM Percent of Total	47.1%	39.3%

Source: Miller 1996.

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Commissioners every 2 years. The committee's first task was to gather information and conduct a survey to identify county needs and priorities. One of the results was the establishment of a revolving loan program to aid local businesses. In addition, business associations have been created in several local communities to focus business activities, and the Task Force is coordinating with the Butte Business Association for development in the I-90 corridor. To improve public relations, three visitor centers are planned - one at the Golden Sunlight Mine, and one each in the north and central parts of the county (Bartlett 1996).

III.K HAZARDOUS MATERIALS AND WASTES

GSM currently transports process and mining-related chemicals to the mine by truck from a variety of locations depending on the availability and price of the chemicals. For instance, sodium cyanide shipments can come from as far away as Carlin, Nevada, or Salt Lake City, Utah. All trucks approach the mine by traveling along I-90 to Cardwell, Montana, then take Montana Highway 2 east to the mine access road. The mine's facilities are located approximately 7 miles from the Cardwell exit on I-90. Once off the interstate, this route follows the Jefferson River for approximately 1 mile and crosses several intermittent streams. These adjacent wetlands and stream crossings represent about 4 miles of the total haul distance. An inventory of the currently transported hazardous materials is presented in Table III-19. Although not currently used at the mine, sulfur dioxide is included in Table III-19 since it will be used in the cyanide destruction process currently under construction. This process is considered to be part of the baseline operations at the site.

Golden Sunlight Mine is currently classified as a small quantity generator of hazardous waste under the RCRA. GSM currently has these hazardous wastes transported off-site to an approved hazardous waste recycler or disposal facility. Details concerning the waste handling practices at the mine are discussed under Hazardous Materials Management in Section II.B.1.a, Current Mining Operations.

Table III-19

Hazardous Materials List and CERCLA Reportable Quantities

Material	CERCLA Reportable Quantity (lbs)
Hydrochloric Acid	5,000
Sodium Cyanide	10
Sodium Hydroxide	1,000
Diesel Fuel	25 gal
Gasoline	25 gal
Petroleum Oils	25 gal
Antifreeze[1]	1
Solvents	100 to 5,000
Sulfur Dioxide[2]	NA[3]

[1] Reportable quantity for ethylene glycol.

[2] Expected use to begin in August 1997.

[3] Not Applicable - No CERCLA Reportable Quantity Exists

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III.L CULTURAL RESOURCES

III.L.1 Background

Cultural resources consist of prehistoric and historic archaeological deposits; structures of historic or architectural importance; and traditional ceremonial, ethnographic, and burial sites. Analysis of cultural resources can provide valuable information on the cultural heritage of local citizens and regional populations. Cultural resources are nonrenewable resources, which are afforded protection by federal, state, and local laws, ordinances, and guidelines. The following federal legislation has been enacted to protect cultural resources and have been considered during review of the proposed project. Details on these acts, as available, are provided in Appendix G.

- The Antiquities Act of 1906 (PL 59-209) and the Archaeological Resources Protection Act of 1979 (PL-96-95).

- National Historic Preservation Act of 1966, as amended; Section 106 Compliance; 16 United States Code 470 et seq., and implementing regulations 36 CFR 800.

- American Indian Religious Freedom Act of 1978; this act requires federal agencies to evaluate their policies and procedures with the objective of protecting the religious freedoms of Native Americans.

- Native American Graves Protection and Repatriation Act of 1990; although specific actions are required in this act, to date no implementing regulation has been promulgated.

III.L.2 Cultural Setting

III.L.2.a Prehistoric Background

The Golden Sunlight Mine is located on the edge of the Northwestern Plains and within the Intermountain region. It lies at the juncture of the Northwestern Plains Culture Area, the Great Basin Culture Area, and the Columbia Plateau Culture Area (Herbort 1985; Steere 1980).

Previous archaeological studies in the region have indicated that the area has seen human occupation from at least 5,000 years B.P. The Lindsey-Mammoth site near Glendive, Montana, has yielded the earliest known occupation dates in Montana of approximately 11,900 B.P. The Whitehall area has been occupied on a sporadic basis since at least the Late Paleo-Indian period (8,000 to 7,500 years B.P.) with the heaviest use areas appearing to have been concentrated near the Jefferson River. Natural springs also appear to have experienced frequent utilization. At least three springs are located within Golden Sunlight Mine's existing and proposed permit boundary areas. Two of the springs (site 24JF717 and 24JF292; the Sheep Rock site) show evidence of human use dating back 8,000 years B.P. or more (Peterson and Mehls 1994).

During the Paleo-Indian period of 12,000 to 7,500 years B.P., the culture appears to have been largely dependent upon hunting of large mammal species, primarily mammoth and bison. Towards the end of the period, some groups were beginning to diverge from an intensive big-game hunting emphasis towards a more wide ranging hunting and gathering subsistence base. Populations experienced a slight increase and groups tended to occupy the foothill and mountain areas (Herbort 1985; Peterson 1990).

The Archaic period of prehistory (7,500 to 1,500 years B.P.) was marked by an increase in temperatures and summer precipitation patterns and an expansion of the grasslands to the north and east during the earliest portion of the period. Populations appear to have increasingly moved into the foothills and higher elevation areas and developed a growing dependence on the use of an extremely diverse resource base with an emphasis on plant foods. Use of the bow and arrow and pottery appear to have developed late in this period. Late in the Archaic, subsistence focused on heavy utilization of bison (Peterson 1990).

The late Prehistoric period on the northwestern plains (1,500 years B.P. to Euro-American contact) saw the continuation of relatively broad-based hunting and gathering patterns, with a continued emphasis on bison. Populations moved significantly during this period and migrations entered the area from the north and east (Peterson 1990).

The introduction of the horse into the Plains culture in the early to middle part of the 18th century brought about substantial changes in the hunting and mobility patterns of the cultures in the area. Following contact with Euro-Americans, the introduction of metal projectile points and knives, metal pots and pans, canvas, and other trade goods also eliminated the need for many traditional skills and technologies within a short period (Peterson 1990).

Tribes living near the Golden Sunlight Mine area during the first contact with Euro-Americans included the Tukudika Shoshone who inhabited the high mountain areas such as Yellowstone Park, and the Crow, Salish, and Bannock. The Blackfeet, Sioux, Atsina, Pend d'Oreille, and Nez Perce were frequent visitors (Herbort 1985).

III.L.2.b Historic Background

The first recorded Euro-American presence identified in the vicinity of the Golden Sunlight Mine area was the Lewis and Clark expedition in 1805 and 1806. The party passed within 2 miles of the mine area as they travelled westward along the Jefferson River in 1805 and again in 1806, when Captain Clark's party passed by on their way east. Fur trappers and traders used the area for the next several decades following the expedition, however permanent settlements in the region were not established until 1863 or 1864, when the first settlers moved into the Whitehall area and developed agricultural operations in the Jefferson Valley (Peterson 1991). The present site of Whitehall was established when the Northern Pacific Railroad came through in 1889, and grew as a distributing center for surrounding farms, ranches, and mining camps (Steere 1980).

The first mining claim in the area was staked in 1890 when gold was first discovered. The American Development and Mining Company began staking claims in 1890 and built a stamp mill in 1895. GSM's group of claims are located in the Cardwell Mining District, which, with the Mayflower and Renova areas, constitutes the greater Whitehall Mining District. GSM's claim properties were held by many owners between the turn of the century and the 1950s, and numerous small gold, silver, and copper underground workings with varied returns were started on them. Ore was processed in a series of mills, including a 40-ton cyanide mill constructed in 1906 and a mill constructed in the early 1950s that processed tailings. Exploration and small-scale underground mining continued in the project area until 1958, when American Exploration and Mining, Inc. (GSM's predecessor) acquired the property. American Exploration and Mining, Inc. held the property for 25 years until the 1970s when exploration and pre-development intensified. Open pit mining began on the property in 1983 (Peterson 1991; Steere 1980).

Five homesteads were filed on in Section 32 in the project area between 1895 and 1915. They included the Bayer, the Scott, the Tebay, and the Mountjoy (2) homestead claims (Steere 1980).

III.L.3 Cultural Resources Identified in the Project Area

Several previous archaeological surveys have been conducted in the vicinity of the existing and proposed permit boundary areas. Tables III-20 and III-21 summarize the surveys and identify the sites located during the inventories. Map III-7 identifies the boundaries of the cultural surveys conducted in the area.

Reports detailing the results of intensive archaeological evaluations conducted in the Golden Sunlight Mine area are on file at the BLM office in Butte, Montana and at the state offices in Helena, Montana. Only brief summaries and general location descriptions are provided in the EIS to protect the confidentiality of the sites.

Table III-29

Cultural Resource Inventories Completed Within Golden Sunlight Mine's Proposed Permit Boundary

Report Title	Reference	BLM Report Number	Number of Sites Recorded In or Adjacent to the Proposed Permit Boundary (sites may be duplicated between inventories)
Montana State University Survey of Sheep Creek/Conrow Creek Stock Watering Project	Steere 1980	97-MT-070-075-01	3
Sunlight Spring and Sheep Spring Development	Miller 1980 a,b	80-MT-070-075-11	0
Cultural Resource Inventory and Evaluation of 640 acres of Placer Amax Inc. Mining Properties	Steere 1980	–	3
1982 Tebay Pipeline Survey	Taylor 1982a	82-MT-070-075-14	1
Western Mountain Transmission Line	Taylor 1982b	–	3
Bull Mountain Access Road Upgrade	Taylor 1983	83-MT-070-075-09	0
Cultural Resource Investigation and Assessment of the 1,842-acre Golden Sunlight Mine/State of Montana Land Exchange	Herbort 1985	–	5
Tebay Pipeline Expansion	Taylor 1985	85-MT-070-075-25	0
Cultural Resource Inventory on 310 acres for a Proposed Exploratory Drill Hole Program	Peterson 1990	90-MT-070-075-30	9
A Cultural Resource Inventory on 640 acres for the Golden Sunlight Mine Expansion Area in Jefferson County, Montana	Peterson 1991	–	0
Museum of the Rockies Survey of a 320-acre Tract in Section 18	Davis 1993	93-MT-070-075-54	0
A Class III Cultural Resources Inventory of Approximately 3,277 acres for Golden Sunlight Mine, Inc.	Peterson and Mehls 1994	94-MT-070-075-07	78 sites, 57 isolated features
A Cultural Resources Inventory of 340 Acres and Testing/Evaluation of Eight Sites for Golden Sunlight Mine Land Exchange	Peterson 1998	98-MT-070-075-05	12

Table III-21

Golden Sunlight Mine Cultural Resources Sites Located Within or Adjacent to the Proposed Permit Boundary

Site Number	Site Description	Project Association	NRHP Status	SHPO Concurrence	Eligibility Criteria	Land Ownership	Reference
24JF227	Lee Ring site; stone circles, grinding stone	Tailings Impoundment No. 1	J (previously disturbed)	No; declined to comment	–	GSM	Steere 1980
24JF228	Ralph's Place; hearths, lithic scatter	Tailings Impoundment No. 1	J (previously disturbed)	No; declined to comment	–	GSM	Steere 1980
24JF229	Mountjoy-Wagoner Homestead	Tailings Impoundment No. 1	J (previously disturbed)	No; declined to comment	–	GSM	Steere 1980
24JF292	Sheep Rock Spring site; hearth, lithic scatter	East Waste Rock Dump Expansion	E	Stanfill 12/20/85	d	GSM	Steere 1980; Herbort 1985
24JF293	Lithic scatter	North side of East Waste Rock Dump Expansion	NEL	Stanfill 12/20/85	–	GSM	Steere 1980; Herbort 1985
24JF288	Lithic scatter	East of East Waste Rock Dump Expansion	NR	No	–	State	Steere 1980
24JF711	Cairns; stone circle; lithics	Rattlesnake Block Buttress	NEL	Wilmoth 1987a	–	GSM	Taylor 1982b; Peterson 1980
24JF712	Sheep rock site; Prehistoric and historic components; bone charcoal and lithic scatter (quarry)	North of East Waste Rock Dump	E	Wilmoth 1987a	a, d	GSM	Taylor 1982b

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Table III-21 (Continued)

Site Number	Site Description	Project Association	NRHP Status	SHPO Concurrence	Eligibility Criteria	Land Ownership	Reference
24JF713	Lithic quarry and processing site	North of West Waste Rock Dump	NEL	Wilmoth 1996	–	GSM	Taylor 1982b; Peterson 1996; Peterson & Mehls 1994
24JF717	Prehistoric and historic remains	North edge of west side permit expansion	E	Warhank 1995	d	BLM	Taylor 1982a; Peterson & Mehls 1994
24JF762	Sheep Rock rings; stone circles, lithic scatter, temporary camp	North side of East Waste Rock Dump	JI	No	–	GSM	Herbort 1985
24JF763 to -766	Prehistoric camps, lithic scatter, quarry stone circle	–	NEL	Stanfill 1985	–	GSM	Herbort 1985
24JF937 to -941, -943	Trash scatter, prospect pits, Bunkhouse and shack, rock cairns	–	NEL	Warhank 1995	–	–	Peterson 1990
24JF942	Rock cairns	Rattlesnake Block Buttress	NEV	Warhank 1995; Wilmoth 1997a	–	GSM	Peterson 1990
24JF944	Firepit	Rattlesnake Block Buttress	NEV	Warhank 1995; Wilmoth 1997a	–	GSM	Peterson 1990
24JF990, -992,	Historic mining operations	–	NEL	Wilmoth 1996	–	BLM/GSM	Peterson 1996

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Table III-21 (Continued)

Site Number	Site Description	Project Association	NRHP Status	SHPO Concurrence	Eligibility Criteria	Land Ownership	Reference
61 sites (24JF1051 to -1061, -1064 to -1068, -1070 to -1072, -1074 to -1076, -1078 to -1088, -1091, -1093, -1094, -1096, -1098 to -1105, -1107 to -1122, -1124	Historic mining complexes, historic trash scatters, historic structures, quarry, historic ranching complex, historic road; developed spring, talus pits, lithic scatters	–	NEL	Warhank 1995; Wilmoth 1996	–	BLM/ Private	Peterson & Mehls 1994; Peterson 1996
57 isolated features (24JF1125 to 24JF1181)	Roads, adits, shafts, test pits	–	NEL	Wilmoth 1997b	–	BLM/ Private	Peterson & Mehls 1994; Peterson 1996
24JF1062*	Talus Pit	West of West Waste Rock Dump Expansion	E	Wilmoth 1996	a	BLM	Peterson & Mehls 1994
24JF1063*	Talus Pit	West of West Waste Rock Dump Expansion	E	Wilmoth 1996	a	BLM	Peterson & Mehls 1994
24JF1069	Historic mining complex	North edge of west side permit expansion	E	Warhank 1995; Wilmoth 1996	–	BLM	Peterson & Mehls 1994; Peterson 1996
24JF1073*	Talus Pit	West edge of west side permit expansion	E	Wilmoth 1996	a	BLM	Peterson & Mehls 1994
24JF1077	Historic mining complex	North edge of west side permit expansion	E	Warhank 1995	–	GSM	Peterson & Mehls 1994

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Table III-21 (Continued)

Site Number	Site Description	Project Association	NRHP Status	SHPO Concurrence	Eligibility Criteria	Land Ownership	Reference
24JF1089*	Talus Pit	West of West Waste Rock Dump Expansion	E	Wilmoth 1996	a	BLM	Peterson & Mehls 1994
24JF1090*	Talus Pit	West of West Waste Rock Dump Expansion	E	Wilmoth 1996	a	BLM	Peterson & Mehls 1994
24JF1092	Historic homestead	East side of Tailings Impoundment No. 2	E	Warhank 1995	–	Private/ GSM	Peterson & Mehls 1994
24JF1095	Ranching feature complex	East side of Tailings Impoundment No. 2	E	Warhank 1995	–	Private/ GSM	Peterson & Mehls 1994
24JF1097*	Talus Pit	West of West Waste Rock Dump Expansion	E	Wilmoth 1996	a	BLM	Peterson & Mehls 1994
24JF1106	Historic mining complex	North side of west side permit expansion	E	Warhank 1995	–	Private/ BLM	Peterson & Mehls 1994
24JF1123*	Talus Pit	West of West Waste Rock Dump Expansion	E	Wilmoth 1996	–	BLM	Peterson & Mehls 1994
None Identified	Whitehall Mining District	–	NEL	Wilmoth 1997b	–	BLM, GSM, State	Peterson & Mehls 1994

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Table III-21 (Continued)

FOOTNOTES:

E - Eligible to the NRHP with SHPO concurrence.
JE - Unevaluated; recommended eligible (pending SHPO concurrence).
JI - Unevaluated; recommended ineligible (pending SHPO concurrence).
NEL - Not eligible to the NRHP with SHPO concurrence.
NEV - Additional information required per agency recommendation; unevaluated.
NR - No recommendation.
GSM - Golden Sunlight Mine.

National Register of Historic Places Eligibility Criteria:

a - Sites that are associated with events that have made a significant contribution to the broad patterns of history.

b - Sites that are associated with the lives of persons significant in our past.

c - Sites that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction.

d - Sites that have yielded, or may be likely to yield, important information on prehistory or history.

[*] Protected under patent restriction/preservation covenant.

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A survey was conducted in 1980 by Montana State University in the area north and east of the Golden Sunlight Mine's existing permit boundary as part of the Sheep Creek/Conrow Creek Stock-Watering project. This survey identified three sites within the proposed permit boundary, including lithic scatters (24JF293, 24JF298) and a lithic scatter and buried hearth at the Sheep Rock Spring site (24JF292) (Steere 1980). The Sheep Rock site is eligible to the National Register of Historic Places (NRHP) with SHPO concurrence; site 24JF293 has been determined ineligible by the BLM with SHPO concurrence and an eligibility recommendation for site 24JF298 has not been made (Stanfill 1985).

The BLM conducted surveys of the SW¼ NW¼ S30, T2N, R3W and the SW¼ of S17, T2N, R3W in August 1980 as part of the Sunlight Spring and Sheep Spring Developments. No sites were identified during these surveys (Miller 1980 a,b).

In September 1980, the Mineral Research Center in Butte, Montana, conducted a survey of approximately 640 acres of private land in the southeastern portion of GSM property. The survey identified two prehistoric sites within the proposed permit boundary, including hearths and a lithic scatter at Ralph's Place (24JF228) and three stone circles and a grinding stone at the Lee Ring site (24JF227), and the historic Mountjoy-Wegener Homestead (24JF229). The sites were determined ineligible to the NRHP by the BLM pending SHPO concurrence (Steere 1980). Work conducted in the Tailings Impoundment No. 1 area under the existing permit has buried these sites.

The BLM conducted Class III surveys along the proposed Tebay Pipeline Route in Sections 1, 12, 13, 14, T2N, R3W in June and September 1982. One site, 24JF717, was identified within the proposed permit boundary. Site 24JF717 has prehistoric and historic components with NRHP potential. Test excavation was recommended (Taylor 1982a). Site 24JF717 was identified as eligible to the NRHP with SHPO concurrence in 1995 (Warhank 1995).

In November 1982, the BLM conducted a Class III survey of the Western Microwave Transmission Line. Three sites (24JF711, -712, and -713) were located within the proposed permit boundary. Site 24JF711 contains cairns and a stone circle, site 24JF712 is associated with the Sheep Rock site, and site 24JF713 is a lithic procurement and processing site (Taylor 1982b). Sites 24JF711 and 24JF712 were determined ineligible and eligible, respectively, to the NRHP with SHPO concurrence (Wilmoth 1997a). Site 24JF713 was determined ineligible with SHPO concurrence (Wilmoth 1998).

In 1983, the BLM conducted a Class III survey as part of the Bull Mountain Access Road Upgrade; no sites were identified during this survey (Taylor 1983).

In April and May 1985, GCM Services, Inc. of Butte, Montana, conducted a cultural investigation of approximately 1,642 acres of state-owned lands that were being considered as part of a land exchange between the state and GSM. The survey identified five prehistoric sites within the proposed permit boundary (24JF762 to -766) (Herbort 1985). Two sites (24JF292 and 24JF293) previously identified in 1980 also were further evaluated for NRHP eligibility. All of the sites with the exception of 24JF292, or the Sheep Rock site, and site 24JF762, were found ineligible to the NRHP with SHPO concurrence (Stanfill 1985). Site 24JF292 was identified as a significant site eligible to the NRHP, based upon its potential to yield data relating to spatial patterning, lithic technology, and subsistence patterns (Stanfill 1985). The site was found to contain 5 to 10 buried cultural levels and significant paleontological deposits (Herbort 1985). Site 24JF762 and has been determined ineligible to the NRHP by the BLM pending SHPO concurrence. Site 24JF766, or the Coulee Ring Site, was directly impacted by construction of the Tailings Impoundment No. 2 dam under the existing permit. Prior to construction of the dam, the site was formally tested to determine if it contained archaeologically significant deposits. As a result of the testing, site 24JF766 was found to be ineligible to the Register, and no further work was recommended (Herbort 1995; Schwab 1990, GSM 1995a; Stanfill 1995).

GSM and the state entered into a memorandum of agreement (MOA) as a result of the 1995 survey and as a condition of the land exchange. The conditions of the MOA included annual MDSL inspection of the Sheep Rock site (24JF292), notification of the SHPO by MDSL if any adverse impact to the site occurs, and a commitment that, should any mine-related disturbance of the site be proposed, appropriate mitigation measures would be promptly conducted (GSM 1995a).

An extension of the Tebay Pipeline was inventoried by the BLM in June 1995; no sites were identified during this survey (Taylor 1995).

In September 1990, Western Cultural Resource Management (WCRM) performed a Class III intensive cultural resources inventory on approximately 310 acres of GSM land in the north half of Section 29. The inventory resulted in the recording of seven sites (24JF937 to -942, -944), including two historic trash scatters and/or structures, two groups of prospect pits, an adit, and two rock cairns. An isolated find (24JF943) also was recorded. Site 24JF711, previously recorded by the BLM Butte District during a 1982 survey of the Tebay Pipeline, was revisited (Peterson 1990). All of the sites, except 24JF942, and -944 were determined ineligible to the NRHP with SHPO concurrence. Sites 24JF942 and -944 were considered eligible pending further evaluation (Warhank 1995; Huppe 1994; Wilmoth 1997a).

WCRM performed a cultural resources survey on 640 acres of state land in February 1991, in preparation for a drilling program. The inventory did not identify any sites within the proposed permit boundary (Peterson 1991).

During an annual inspection and excavation of the Sheep Rock site (24JF292), Museum of the Rockies representatives conducted a survey of the east half of S18, T2N, R3W. No sites were identified during the survey (Davis 1993).

Between September and October 1993, WCRM performed an inventory of approximately 3,163 acres of public and private land in the northwest and central portion of the Golden Sunlight Mine as part of the requirements for a proposed land exchange between GSM and the BLM. An additional 115 acres also were surveyed around the mine's water intake area, south of I-90, in advance of a potential pond expansion for gravel recovery. The inventory resulted in the recordation of 74 prehistoric and historic sites (24JF1051 to -1124) and 57 isolated mining features (24JF1125 to 24JF1181). The prehistoric sites included both lithic scatters and talus pits tentatively identified as hunting blinds. The historic sites were generally related to mining features dating between the late 1800s to the mid 1900s. Two sites previously recorded during the 1982 Tebay Pipeline survey also were revisited (24JF713, 24JF717) (Peterson & Mehls 1994). In addition, WCRM also evaluated the potential for the Whitehall Mining District, which the project area lies within, to be eligible to the NRHP. The Whitehall Mining District essentially covers the southern end of Bull Mountain and portions of over ten sections (17, 18, 19, 20, 29, and 30 of T2N R3W, and 11, 12, 13, 24, and 25 of T2N R4W) on the east and west slopes and the south end of the mountain. The boundaries of the district were defined based upon historic mining and exploration journals, papers, and traces of past operations as seen on the ground. The district was largely developed from 1890 to 1910; the first claims in the Whitehall District were staked in 1890. As a result of its research, WCRM determined that the ongoing pattern of disturbance in the area had negated the potential for the District to be considered as a significant National Register Historic District, particularly because of the loss of setting within the district and salvage operations that had removed or altered a majority of the aboveground structures. The BLM agreed with WCRM's findings and the SHPO concurred that the District was not eligible to the Register in 1997 (Peterson and Mehls 1994; Wilmoth 1997b).

Additional testing and re-evaluation of the sites located during the 1993 survey was conducted by WCRM in July, November, and December 1995. Two parcels of land in the mine area totalling 340 acres also were surveyed. WCRM also conducted testing at 8 previously identified sites (24JF713, -1057, -1081, -1089 -1092, -1100, -1110, -1116). In addition, interviews with local residents who had worked at the mines in the area were conducted to obtain additional information regarding historic mining features in the area (24JF1107) and information on the age of the Whitehall "W" (24JF1104). The survey also resulted in the identification of two new historic archaeological sites (24JF880, 24JF882) (Peterson 1988). Consultation and field trip coordination with Native American groups was conducted by the BLM for talus pit sites identified during the 1988 WCRM survey (24JF1080, -1082, -1083, -1073, -1088, -1090, -1087, and -1123). As a result of the consultations, all of the talus pit sites, with the exception of site 24JF1080, were identified as eligible to the NRHP under criteria "a" with SHPO concurrence (Good 1988; Wilmoth 1988). Additional BLM consultation with the SHPO regarding the findings of WCRM's 1983 and 1985 surveys resulted in a concurrence by the SHPO with BLM determinations that sites 24JF1059, -1077, -1082, -1085, and -1108 also were eligible to the NRHP. The SHPO also concurred with the BLM's determination that sites 24JF0713, -1057, -1081, -1092, -1100, -1104, -1107, -1110, -1116, -0880, -1080, -0882, and isolated occurrences 24JF1125 to -1181, were not eligible to the NRHP (Warhank 1988; Wilmoth 1986 and 1987a).

In summary, a total of 15 sites located within or adjacent to the proposed permit boundary have been identified by the BLM as eligible to the NRHP with concurrence from the SHPO. These include sites 24JF 292, -712, -717, -1082, -1083, -1059, -1073, -1077, -1088, -1090, -1082, -1085, -1087, -1108, and -1123. In addition, seven unevaluated sites lie within or adjacent to the proposed permit boundary. These include site 24JF298, which has not received a determination; sites 24JF227, -228, and -229, which the SHPO has declined to comment on since the sites are assumed to have been destroyed; site -782, which has been determined ineligible to the NRHP by the BLM, but still requires SHPO concurrence; and sites 24JF942 and -944, that require additional data collection before a determination can be made. Depending upon final SHPO concurrence received on these seven sites, and until this concurrence is received, these sites should be treated as potentially eligible to the NRHP.

III.M NATIVE AMERICAN CONCERNS

III.M.1 Ethnography

Native American tribes that lived in, utilized, or travelled through the Jefferson Valley and Whitehall area included the Blackfeet (Piegan), Flathead, Bannock, Crow, Sioux, Atsina, Pend d'Oreille, Nez Perce, and Shoshoni (Stuart 1982; Harbort 1985). Kiowa tradition indicates that they were located at one time near the confluence of the Jefferson, Madison, and Gallatin Rivers, approximately 20 miles east of the Whitehall area. Prehistorically, the Shoshone appeared to have inhabited the study area but were eventually forced to abandon the area. The Flathead also appear to have had traditional use of the area, but also were forced out shortly prior to the first Euro-American presence in the region. By the time of the Lewis and Clark expedition, the Blackfeet were the major military power in the area (Peterson 1985).

Wickiups, game drive sites, campsites with steatite bowls, pottery, and chipped stone tools are reported in connection with the Shoshone sites in southwestern Montana (Harbort 1985). The Madison Buffalo Jump, approximately 20 miles east of Whitehall was used repeatedly over several thousand years (Harbort 1985).

III.M.2 Native American Consultation

Recent legislation and regulations provide for federal agencies to consult with Native Americans before certain types of land or resource management decisions are implemented. These acts and regulations, which provide a measure of protection to Native American religious and traditional use sites and other cultural beliefs and practices, are the American Indian Religious Freedom Act, the Religious Freedom Restoration Act, the Archaeological Resources Protection Act, the National Historic Preservation Act as amended to provide a role for Indian Tribes in Section 106 consultation provisions, and the Native American Graves Protection and Repatriation Act. Also, the state of Montana is required to comply under the Montana Human Remains and Burial Site Protection Act. Traditional use sites can be nominated to the NRHP following criteria outlined in National Register Bulletin 38. Traditional use sites that are found eligible are given the same protection under the NRHP Act that are afforded other cultural properties.

As part of the consultation process, seven reservations, colonies, and Native American organizations were notified by the BLM Butte District office via the January 1996 edition of the District's Quarterly Project List about the Proposed Action and were provided with the opportunity to comment on the project. These groups included the Blackfeet, Crow, Salish-Kootenai, and the Shoshone-Bannock Tribes, representatives at the Flathead Indian Reservation, Crow Indian Reservation, the Northern Cheyenne Reservation, the Wind River Shoshone Reservation, and the Rocky Boy's Indian Reservation. Extensive coordination regarding site 24JF717 and seven talus pit sites located in Section 25 (24JF1082, -1083, -1073, -1088, -1080, -1097, -1123) also has been conducted with the Flathead Culture Committee of the Confederated Salish and Kootenai Tribes and the Land Use Policy Commission of the Shoshone-Bannock Tribes in regard to a proposed land exchange between the BLM and GSM. Representatives of the Shoshone-Bannock Land Use Policy Commission and the Flathead Culture Committee have indicated that the talus pit sites are important and should be protected. As part of a proposed treatment plan under the land exchange, requests for a patent restriction that places a protective covenant around the talus pit sites in Section 25 were made (Good 1996). Upon approval of the patent restriction, ground disturbing actions and other land use activities could not legally take place within the settings of the talus pits.

The BLM recommended consultation with Native Americans on sites 24JF942 and -944. The SHPO concurred with this recommendation, and on July 9, 1997, a representative for the Confederated Salish and Kootenai Tribes and BLM and GSM employees met at the mine to evaluate sites 24JF942, -944, and -298 for potential interest to Native Americans. At the time of the visit, the tribal representative expressed concern that site 24JF944 may be a potential burial location. No concerns were identified for sites 24JF942 and -295. Following the visit, limited archeological investigations were conducted at the sites to determine if they contained buried materials; no buried materials were found at the sites. BLM has recommended that the sites not be considered for listing in the NRHP and is waiting for final agreement with this recommendation from tribal representatives before presenting their findings to the SHPO (Sanders 1997).

No letters, comments, or telephone calls have been received as of the date of this printing from any of the tribal representatives contacted via the Quarterly Project list. A copy of the Quarterly Project List is available from the BLM Butte District office in Butte, Montana.

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CHAPTER IV

Environmental Consequences

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IV ENVIRONMENTAL CONSEQUENCES

IV.A GEOLOGY, MINERALS, AND PALEONTOLOGY

IV.A.1 No Action Alternative

IV.A.1.a Geologic Impacts Associated with Discontinued Mining

The most significant impacts that are associated with the geological resources are related to ground movements at the Golden Sunlight Mine and resulting impacts to the plant site buildings, existing pit, waste rock dumps, and tailings impoundments. Impacts associated with ground movements are discussed in terms of two interrelated concepts: potential (or likelihood) that movement will occur and consequences associated with movement, if it does occur.

Potential for Earth Movements

General Considerations: Stability under Static and Earthquake Loading Conditions. This section describes the potential for movement, settlement, or sliding of earth structures and/or natural landslide features under the No Action Alternative. Earth facilities include the pit, waste rock dumps, tailings impoundments, and waste rock buttresses. Potential settlements in structural foundations in the plant site area also are discussed.

The stability of an earth slope typically is expressed as a factor of safety. A factor of safety equal to 1 indicates that the slope is just strong enough to support itself without slumping or sliding. Engineers typically design structures to have factors of safety greater than 1 to account for unanticipated loading and uncertainties about the strength of the structure.

Two different loading conditions are analyzed for earth structures: normal static conditions and earthquake conditions. Evaluating the static factor of safety for an existing man-made or natural earth slope involves a number of assumptions and interpretations about potential modes of failure, subsurface conditions, and shear strength of the soil materials. The fact that the slope exists and is stable indicates that the static factor of safety is at least 1. Typical minimum static factors of safety used to design stable man-made earth slopes, or to assess the adequacy of stability of an existing slope, range from about 1.2 to 1.5. These values indicate that the forces tending to resist sliding are estimated to be at least 20 to 50 percent greater than the forces tending to drive the mass downhill. Lower static factors of safety (1.2 to 1.3) are allowed for non-critical structures or for short-term loading conditions, such as during construction. Lower static factors of safety also are allowed when more detailed geotechnical evaluations are conducted, thus increasing the confidence in interpretations of material strengths, subsurface geometry, and groundwater conditions. Higher static factors of safety (typically 1.5 minimum) must be used for critical facilities, such as high hazard embankment dams where catastrophic failure could lead to loss of life.

Earthquake slope stability evaluations are handled somewhat differently. During an earthquake, most earth slopes are not susceptible to catastrophic failure, but instead may respond to an earthquake by progressively deforming in response to each cycle of shaking. The earth slopes and landslide masses at Golden Sunlight Mine would respond in this manner. The seismic stability concern for earth slopes is not an issue of whether catastrophic failure might happen, but how much displacement might occur as a result of the earthquake. The total amount of deformation that may develop depends on the strength and mass of the material, the geometry of the slope, and the duration and magnitude of the earthquake shaking.

Rigorous engineering analyses were performed to estimate deformations of critical earth structures and landslide features at the Golden Sunlight Mine. These analyses accounted for both the amount of displacement that would be attributed directly to the ground shaking (called acceleration-induced displacement), plus any additional displacement that would be associated with inertia forces. Acceleration-induced displacements were computed for the most critical (lowest factor of safety) cross sections identified by the static analyses. Inertia-induced displacements are essentially independent of the static factor of safety of the slope.

Earthquakes also may cause ground settlements beneath structures at the mill site. The soils that underlie buildings at the mill site have a very low risk of liquefaction failure that would result in sudden collapse of the foundation soils under earthquake loading. This low probability is because the groundwater table is well below the ground surface (at depths greater than 60 feet). But there is a potential for some ground settlements within the dry to moist foundation soils as a result of earthquake shaking. Analyses were carried out to determine the potential for settlement and the consequences of these movements.

Seismic analyses were done for a design earthquake event known as the maximum credible earthquake (MCE). The MCE is based on regional seismicity studies, such as were described in Section III.A.2.c, Faulting and Seismicity. The MCE for the mine vicinity was estimated to be a magnitude 7.5 earthquake, originating from an epicenter approximately 30 miles from the mine. The duration (number of cycles) of shaking is directly related to the earthquake magnitude, and the horizontal ground acceleration at a given location is related to the magnitude, epicentral distance, and geology. Both duration and peak horizontal ground acceleration are used in seismic slope deformation analyses. The peak horizontal ground acceleration that is estimated to occur at the mine site during the MCE is 20 percent of gravitational acceleration (0.2 g). Regional seismic zoning studies indicate the likelihood that the site will experience peak ground accelerations of this magnitude have a 90 percent probability of not being exceeded in 50 years (Algermissen et al. 1982). This level of seismic shaking coincides with that of an event having a 475-year return period. Thus, the chances that the site will experience the MCE during the remaining operational life of the mine are very small. And, although smaller, closer earthquakes have a higher probability of occurring during the mine life, most would be nondestructive. Therefore, the environmental consequences analyses are performed for the MCE only.

Predicted Factors of Safety and Seismic Deformations

Table IV-1 summarizes the computed minimum factors of safety for static failure of man-made slopes at the Golden Sunlight Mine and for further movement of the block slips for the ground conditions that exist under the No Action Alternative. The factors of safety shown on Table IV-1 are the minimum values obtained after analyzing many possible failure scenarios. In the cases of the constructed waste rock dump and buttress slopes, these minimum factors of safety typically pertain to a localized portion of the structure and are not necessarily representative of the stability conditions at all locations. Potential localized ground displacements due to the design earthquake also are shown on Table IV-1. The implications of these factors of safety and ground displacements are discussed in the following paragraphs.

Potential for Movement of Block Slips and Constructed Slopes

Natural landslide features at the Golden Sunlight Mine include the Midas Slump and the Sunlight, Rattlesnake and Swimming Pool block slips. These features are outlined on Map III-3 in Chapter III. The Midas Slump, a shallow landslide underlying the east dump area, was stabilized by waste rock buttressing in 1993. Mining activities caused the Sunlight, Rattlesnake and Swimming Pool block slips to move 3.5 to 4 feet in April 1994. The block slips were quickly stabilized by corrective waste rock removal and construction of earth buttresses. Block slip movements were halted by October 1994, and the blocks have been carefully monitored for additional movement since then.

No additional block slip movements were detected subsequent to the 1994 event, until minor block slip movements occurred on the Rattlesnake Block between September and November 1996. These movements were attributed to reclamation construction activities ongoing at that time on the south face of the

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Table IV-1

Summary of Mass Slope Stability for Critical Earth Structures/Features
No Action Alternative

Feature	Minimum Factor of Safety			Seismic Deformation (ft)	Reference
	Constructed Slopes				
	As Built	Reclaimed	Block Slip		
Sunlight Block with Interim Buttress	–	–	1.20	6	Golder 1995j, 1996a
Interim Buttress	1.2	1.3	–	2 to 4	Golder 1995j
Interim East Dump (East Face)	1.6	N.A.*	–	N.A.	Golder 1995c, 1995d
Interim East Dump (South Face)	1.2	1.2	–	3 to 7	Golder 1995c, 1995d
Interim West Dump	1.4	1.9	–	2 to 5	Golder 1995k
Tailing Impoundment No. 1	3.9	N.A.	–	negligible	AGRA 1995
Tailing Impoundment No. 2	4.4	N.A.	–	negligible	AGRA 1995

N.A. = Not analyzed.

N.A.* = Not analyzed for the proposed reclaimed slope angle of 2H:1V; min. FS = 1.4 for a 3H:1V reclaimed slope. The reclaimed configuration is slightly less stable than the as-built configuration at one specific location on the dump face. This peculiarity is due to the concave face shape (in plan view) at that location, which results in increased waste volume on that section after reclamation.

– = Not applicable.

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Interim Block Buttress. Small movements on the order of 0.5 inch were detected in two inclinometers installed on the Rattlesnake Block at locations on the north and south sides of the Interim Block Buttress III. Follow-up measurements of the inclinometers in December 1996, indicated that the movement had stopped.

Movement of the block slips (i.e., Sunlight, Rattlesnake, and Swimming Pool) was successfully stopped in 1994 by a combination of off-loading of waste rock materials near the head of the Sunlight Block and buttressing at the toe of the Rattlesnake Block (as discussed in Section III.A.2.b, Ground Movements). Under the No Action Alternative, additional waste rock will be placed at the toe of the Sunlight Block. This construction is referred to as the interim buttress, and its extent is shown in plan in Chapter III, Map III-3 under the No Action Alternative. The larger proposed buttress, which also is outlined in Chapter III on Map III-3 and is shown in cross-section on Figure III-4, will not be constructed. It is estimated that the interim buttress will improve to 1.2 the static factor of safety against future sliding of the Sunlight Block. Without the interim buttress, the factor of safety is estimated as 1.11. Modeling indicates that the improved stability that will be provided by the interim buttress will be close to the estimated pre-mining condition.

The minimum operational and reclaimed stability conditions for the interim buttress waste rock dump are indicated by the factors of safety shown for that feature on Table IV-1. The design and construction sequencing of this buttress were optimized to maintain at least a factor of safety of 1.2 for the south face of the buttress, with the ultimate goal of improving the stabilizing effect on the Sunlight Block. The design incorporated the maximum amount of waste rock that could be safely utilized in the available permit area to improve the Sunlight Block stability. The interim buttress was reclaimed in the fall of 1996 at a slope of 3:1 to establish a minimum long-term static factor of safety of 1.3.

Under the No Action Alternative, the eastward extension of the East Waste Rock Dump stops short of crossing the Sheep Rock Creek drainage. The toe of this dump is indicated as the Interim East Waste Rock Dump on Map III-3 in Chapter III. The final, outer slopes of the southeastern part of this dump will be reclaimed at 3:1. At this slope angle the long-term minimum factor of safety for the critical south face of the dump will be 1.2, as indicated on Table IV-1. The acceptance of a low, long-term factor of safety (FS = 1.2) for the south face of the Interim East Waste Rock Dump was supported as follows (Golder Associates Ltd. 1995d):

1. Use of worst-case assumption regarding the location of the weakest potential slip surface.

2. Use of worst-case assumption regarding the shear strength of the potential slip surface. A residual strength equal to the back-calculated shear strength of the presheared zone under the block slips was used. This low strength would only be valid if similar preshearing had occurred in the area beneath the waste rock dump. There was no direct evidence that this area had experienced such preshearing, so this assumption also is considered as worst-case.

3. Relatively extensive geotechnical site investigation, as reported in Golder (1995c), provided a higher level of confidence as to the foundation conditions than is typical for most geotechnical designs. Higher factors of safety are used for designs based on less extensive investigation to compensate for unknown factors.

4. The low factor of safety was computed for a highly localized part of the dump where it sits in the most deeply incised portion of the Midas Creek drainage. The average factor of safety for the south face is estimated to be between 1.3 and 1.4 for as-built and reclaimed configurations, respectively.

The northeast portion of the dump face is proposed to be reclaimed at 2:1. Stability analyses were not performed for this final slope inclination, but these slopes are expected to be stable considering the favorable orientation of the dump slope with respect to the foundation bedding planes.

Mass slope stability (not reclamation criteria) controls the 3:1 reclaimed slope inclinations for both the interim buttress and southeastern face of the interim East Waste Rock Dump. These reclaimed slope angles are shallower than the 2:1 slopes, which are proposed for all the other dumps, including the northeastern face of the interim East Waste Rock Dump. The need for the shallower slopes at these specific locations is attributed to their proximity and orientation with respect to known or potentially weak foundation materials. The foundation conditions at these locations are well understood on the basis of extensive site investigations and back-analyses for material strengths, which were done in connection with the block slip movement evaluations (Golder Associates Ltd. 1998b).

The factors of safety shown on Table IV-1 refer to the normal static conditions. In the event of an MCE, cyclic shaking of the ground may cause some movement of the block slips along the pre-sheared sliding surfaces. Seismic analyses indicate that large scale "failure" of the slope would not occur. However, acceleration and inertia-induced displacements could occur during the earthquake shaking. Engineering analyses indicate that localized displacements of the Sunlight Block up to 6 feet are possible after the interim buttress is emplaced (Golder Associates Ltd. 1998a). This movement is expected to occur primarily along the margins of the block. Movement of the Sunlight Block would probably result in movement within the Rattlesnake Block, including extensional movements within the foundation soils on which the mill structures are supported. Mitigation Measure G-1, Section IV.P, Potential Mitigation and Monitoring, addresses early detection and minimization of future slide block movement.

Earthquake-induced displacements also are possible for the waste rock dumps and buttress, as indicated on Table IV-1. The tailings dam slopes are anticipated to remain stable during the MCE. In none of the cases analyzed for man-made slopes and natural block slips did the seismic analysis indicate catastrophic failure. Seismic displacements shown on Table IV-1 refer to the estimated differential settlement and/or lateral movement to a new, stable ground condition after the earthquake occurs.

__Potential for Consolidation Settlement of Tailings Impoundments__

Settlement of Tailings Impoundment No. 1 could potentially impact the integrity or runoff performance of the reclamation cover system, if left uncorrected. Mitigation Measure G-4 in Section IV.P, Potential Mitigation and Monitoring, addresses this concern. The tailings materials were deposited in a saturated slurry. These material consolidate under their own weight as water is squeezed out of the voids within the deposit. The surface of the tailings settles because of this consolidation process. Consolidation will continue for several years after the tailings facility is closed. The rate of settlement will decrease with time once the impoundment is decommissioned and can be very slow due to the low permeability of much of the tailings material. It is estimated that the tailings could continue to consolidate for up to 20 years after closure. However, it is estimated that 90 percent of the consolidation settlement would occur within about 10 years after closure (Knight Piesold Ltd. 1993).

Ultimate settlements at the surface of the impoundment will be variable and will depend mainly on how the different tailings materials were distributed. Maximum settlements in Tailings Impoundment No. 1 are estimated to be as much as 7 feet. Maximum settlement will occur where thick layers of fine-grained slimes are present, which is in the vicinity of the supernatant pond on the northwest corner of Tailings Impoundment No. 1. The slimes are estimated to be approximately 80 feet thick in that area. Less settlement will occur near the outer perimeter of the impoundment where the deposits are more sandy and are interlayered with fine and coarse tailings. Settlement within Tailings Impoundment No. 2 will be minimal for the amount of tailings deposited at the end of the *Interim Dump Plan*.

Most of the highly settled areas in Tailings Impoundment No. 1 will be infilled as part of the reclamation program. Disruption of the runoff grading over the long-term will be corrected by infilling and regrading as necessary over the consolidation time period (approximately 10 years).

Potential for Movement of Structural Foundations

The primary geologic hazard in the mill site area relates to the presence of potentially collapsible soils, as described in Section II.A.2.g, Plant Site Building Foundations. These potentially unstable soils have significant foundation bearing strength when dry, but tend to collapse when wetted while under high foundation loading. This type of collapse settlement is believed to have occurred in the foundation beneath the pyrite leach tank building in the spring of 1994. Settlements ranging from several inches to feet were attributed primarily to wetting of a localized zone beneath the structure when a water pipe was extended and pulled apart by block slip movements. The exterior, above and below-grade utility lines that are connected to the structures have since been provided with flexible couplings to reduce the chance of waterline failure during any future ground settlements and differential movements (Golder Associates Ltd. 1995a).

During the 1994 ground movement, smaller settlements in the grinding circuit and chemical storage area were attributed to significant lateral ground movements. These movements are directly associated with block slip movements and are not attributable to wetting and collapse. Horizontal displacements in the plant area were estimated to vary from 0.9 to 3 feet, with maximum movement on the eastern edge of the area, decreasing to the west. Vertical settlement associated with this movement varied from 25 to 50 percent of the corresponding horizontal movement (Golder Associates Ltd. 1995b).

The plant site building foundations could undergo permanent vertical settlements in the order of 8 to 16 inches in the event of an MCE. Differential settlements across any structural foundation are estimated to be approximately one-half the total predicted settlements, or on the order of 4 to 8 inches. The large, rigid concrete mat foundation systems, which support the critical machine footings and tanks are expected to withstand earthquake induced differential displacements of this magnitude without excessive tilting, bearing capacity failure, or overturning. It is likely that the foundation systems would require extensive repairs or replacement following a design MCE event (Golder Associates Ltd. 1995a). Lateral movements associated with seismic shaking are expected to be negligible if block slip movement does not occur, and as long as the foundation soils remain dry, the risk of catastrophic earthquake-induced settlements is considered to be small (Golder Associates Ltd. 1995b).

However, the risk of foundation failure is greatly increased if movement in the lateral direction due to block slip movement occurs simultaneously with earthquake-induced foundation settlements. It is unlikely that the flexible utility couplings that have been provided can withstand both vertical shearing on the order of 8 to 16 inches at the same time as extensional spreading. Mitigation Measure G-3 in Section IV.P, Potential Mitigation and Monitoring, addresses potential movement of structural foundations.

Potential Pit Wall Instability

Under the No Action Alternative, the pit area will be approximately 312 acres, with a maximum pit wall height of 1,375 feet. The pit wall angles, bench widths, and bench slope angles will be left generally as shown in the Operating Permit. Over time, it is expected that some portions of the pit walls will be subject to raveling, talus formation, erosion, and limited rock mass movements, thus locally altering the configurations of some of the pit walls. In particular, rock mass movements may be expected along the northwest area of the pit, where the unfavorable orientation of existing faults renders this area less stable. The overall stability of the pit walls is expected to increase over the long-term as rock and soil materials achieve more stable configurations, and as the rock mass surrounding the pit dewaters over time.

The elevation of the pit lake will be between 5,075 and 5,100 feet under the No Action Alternative. As the groundwater levels in the slopes surrounding the pit are drawn down during mining, and maintained following mining, the pit slopes will become more stable. This is because the fluid pressures within the rock mass, which act to destabilize the slopes, will be reduced.

__Environmental Consequences__

Potentially adverse environmental consequences are linked to ground movement potential, using a process known as Failure Modes and Effects Analyses, or FMEA. FMEA is a tool for evaluating risks to the environment by categorizing both the likelihood for ground movement to occur (failure mode likelihood categories) and the associated environmental impacts (consequences categories). The FMEA for potential ground movements is provided in Appendix H.

The results of the FMEA for the No Action Alternative indicate that most of the identified modes of failure have a low to very low probability of occurring. Moderately likely failure modes are primarily associated with potential block slip movements. The only failure modes that have a significant probability of occurring are related to instability (ravelling) of the pit walls and consolidation settlements on the tailing impoundment covers. These potential ground movements are anticipated to have negligible environmental consequences. The failure modes that have the worst environmental consequences (tailings dam failures) have very remote likelihoods of occurring.

IV.A.1.b Paleontological Impacts Associated with Discontinued Mining

Although no fossil-bearing deposits have been identified in the currently permitted area, invertebrate and vertebrate fossils occur in the types of formations that are found in the mine area (Lindsey 1994). Geologic maps of the mine area indicate that occurrences of the Bozeman Group geologic unit, which has been identified as containing significant vertebrate fossils in other localities, are located under the buttress and portions of the tailings impoundments, access road, and diversion area. Occurrences of Pleistocene-age alluvial terrace and fan deposits, which have been identified as containing important paleontological resources in localities adjacent to the existing project boundaries, have been identified in the East Waste Rock Dump, pit, West Waste Rock Dump, buttress, tailings impoundment, diversion, and access road areas. No occurrences of the Miocene-age Six Mile Creek Formation have been identified in the currently permitted area.

Because fossils are usually buried, their locations cannot be confirmed until excavation occurs. Continued placement of tailings in the impoundment areas and the addition of rock and soil to the buttress area and the waste rock dumps under the No Action Alternative will not destroy any known fossil beds but will limit access and restrict future study of potential fossil-bearing deposits. Previously unidentified paleontological resources could be encountered and/or directly impacted during the course of mine operations and reclamation. If significant fossiliferous deposits, specifically Tertiary or Pleistocene vertebrate fossil deposits, are located during construction, operation, or reclamation of the mine under the No Action Alternative, paleontologists from the appropriate state or federal agency should be immediately contacted, and measures taken to identify and preserve the fossils (Mitigation Measure P-1).

Potential indirect impacts could result from continued accessibility to fossil beds via improved transportation routes in the mine area and from continued increases in human activity in the area related to mine work. Potential erosional effects of mine operation could lead to indirect effects to site 24JF292 and other potential fossil-bearing deposits that border or lie within the mine area. Following mine closure, indirect impacts are expected to be slightly reduced with the decrease in human activity in the area.

IV.A.2 Proposed Action Alternative

IV.A.2.a Geologic Impacts Associated with Continued Mining

Potential for Earth Movements

The Proposed Action elements that would change ground movement potential in comparison with the No Action Alternative are:

- Expansion of the East Waste Rock Dump;
- Construction of the proposed buttress; and
- Expansion of the pit.

Static factors of safety against slope failure or block slip movement, and the predicted seismic deformations for earth structures/features relevant to the Proposed Action are summarized on Table IV-2. Stability conditions for the tailings dams are unchanged from the values presented on Table IV-1 and are not repeated on Table IV-2.

East Waste Rock Dump Expansion

Under this alternative, the East Waste Rock Dump would cross the Sheep Rock Creek drainage. The outline of the East Waste Rock Dump is indicated in Chapter III, on Map III-3. The Sheep Rock Creek drainage channel would have to be infilled south of the main dump toe, as shown in Chapter III on Map III-3 and Figure III-6. This channel infill would allow construction of the East Waste Rock Dump across the drainage channel, while keeping the main toe of the dump well north of the possible ancient head scarp of the Sunlight block slip. This possible ancient head scarp is shown in Chapter III on Map III-3. This feature is not associated with any recent ground movements, but has been identified by geologists only as a possible indicator of ancient (Tertiary) earth movements. The channel infill is required to maintain adequate stability of the south dump face, especially in the vicinity of the Sheep Rock Creek drainage where potentially weak foundation soils have been nearly exposed (daylighted) by the incised channel. The final, outer slopes of the entire south face of the East Waste Rock Dump would be reclaimed at 3:1, as dictated by slope stability.

East Waste Rock Dump Slope Stability

A geotechnical site investigation and slope stability analyses were done for the extended East Waste Rock Dump (Golder Associates Ltd. 1995b). Slope failure scenarios for the south face of the extended East Waste Rock Dump were evaluated using conservative 'worst-case' assumptions about foundation conditions. These assumptions included:

1. Use of worst-case assumption regarding the location of the weakest potential slip surface.

2. Use of worst-case assumption regarding the shear strength of the potential slip surface. A residual strength equal to the back-calculated shear strength of the presheared zone under the block slips was used. This low strength would only be valid if similar preshearing had occurred in the area beneath the waste rock dump. There was no direct evidence that this area had experienced such preshearing, so this assumption also is considered as worst-case.

The north and east faces of the extended East Waste Rock Dump were not rigorously evaluated for slope stability factors of safety. However, considering the more favorable foundation conditions beneath those areas, especially the relatively shallow depth to bedrock, and the absence of the weak Bozeman fluvial unit, it is likely that those factors of safety would be within acceptable limits.

Potential for an East Dump-Triggered Block Slip

Additional analyses were performed to evaluate the potential for initiating another large block slip on the slope below the extended East Waste Rock Dump (Golder Associates Ltd. 1995a). These analyses investigated the possibility that placement of the extended East Waste Rock Dump would cause block slip

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Table IV-2

Summary of Mass Slope Stability for Critical Earth Structures/Features
Proposed Action

Feature	Minimum Factor of Safety			Seismic Deformation (ft)	Reference
	Constructed Slopes				
	As Built	Reclaimed	Block Slip		
Sunlight Block with Proposed Buttress	–	–	1.30	4	Golder 1995h, 1996a
Proposed Buttress	1.2	1.3	–	5 to 6	Golder 1995h
East Dump (South Face)	1.3	1.3	–	1 to 2	Golder 1995i
West Dump	1.3	1.7	–	2 to 5	Golder 1995l
East Dump - Triggered Block Slip:					
3D Case 1: Average conditions			1.30	N.A.	Golder 1996b
3D Case 2: Critical dip angle			1.30	N.A.	Golder 1996b
3D Case 3: Critical daylighting condition			1.50	N.A.	Golder 1996b
2D Localized condition			1.10	N.A.	Golder 1996b

N.A. = Not analyzed.

– = Not applicable.

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movements in the Tertiary deposits east of Sheep Rock Creek drainage, similar in nature to the Sunlight and Rattlesnake Block movements. The overall ground stability to the south and west of the proposed dump was evaluated, with the analyses focusing in particular on the following:

- Disruption of Tailings Impoundment No. 2 by
  - Displacement of material at the toe of a failure mass into the impoundment;
  - Daylighting of a potential slip surface within the impoundment (as occurred in Tailings Impoundment No. 1 during the 1994 movement of the Rattlesnake Block); or
  - A massive block movement daylighting south of the impoundment.
- Remobilizing the Sunlight Block by
  - Application of a south or southwest trending force on the east margin of the Sunlight Block; or
  - Generation of a southeast trending drag force on the east margin of the Sunlight Block.

The results of these analyses were interpreted to indicate that (Golder Associates Ltd. 1995b):

- The area of conceivable block slip movement is confined geologically on the east such that movement cannot occur east of Easting 32,500.
- Potential block slip movements that would be associated with placement of the East Waste Rock Dump would daylight well north of Tailings Impoundment No. 2 and would not affect the impoundment.
- The East Waste Rock Dump area is expected to remain stable, and no force transmission to the Sunlight Block is expected.

The detailed geologic model of the East Waste Rock Dump area was developed to provide input parameters for two-dimensional (2D) and three-dimensional (3D) block slip stability analyses. Identifying potential slip surfaces for massive block failures was the most critical component of the model. Sunlight and Rattlesnake block movements were attributed to sliding predominantly along the uppermost clay layer in the Tertiary Bozeman fluvial unit (Tbf), although segments of the slip planes near the margins of the valley extended through places where the fluvial and alluvial facies were mixed (Tbf/Tba). This mode of failure - slip along the shallowest clay layers in Tbf or Tbf/Tba - seemed the most plausible for the East Waste Rock Dump model. There was some concern about a deeper, low strength paleosol (Tgd), which is present in the East Waste Rock Dump area at the upper surface of the bedrock. However, the potential for movement along deeper clay layers due to the East Waste Rock Dump loading was considered to be slight because the cross-bedding strength of the overlying Tertiary materials would prevent deep slip surfaces from breaking through to the surface at their toes. Considering this, in conjunction with the past failure modes of the Sunlight and Rattlesnake blocks, the model was set up to simulate various block slips along the dip directions of the uppermost clay bedding planes in the Tertiary Bozeman facies (Tbf and Tbf/Tba).

A subsurface topographic map of the upper clay surface was developed for the East Waste Rock Dump area based on drill hole information contained in the report entitled *Stability Analysis East Waste Rock Dump* (Golder Associates Ltd. 1995a). Most of this surface comprises the upper clay layers of Tbf and Tbf/Tba. Beyond the limits of the uppermost Tertiary Bozeman clay layer to the north and east, the potential slip surface connects with the Tertiary paleosol (Tgd) at the valley margins. The eastern extent of the potential slip surface is limited by the rising Paleozoic-age bedrock. Moving from east to west the dip of the clay layer transitions from predominantly southwest, to south, to southeast where it meets the eastern margin of the Sunlight Block. The average dip angle of the upper clay beneath and immediately south of the East Waste Rock Dump varies from 4.2° south to 5.7° southwest. It was assumed that potential movement of block slips east of the Sheep Rock Creek drainage would be controlled by the residual shear strengths of the clay layers along these dip directions.

The upper clay surface is daylighted (exposed at the surface) downslope (south) of the East Waste Rock Dump. The southern limit of movement would be controlled by the upper Tbf clay surface exposure closest to the dump. This closest exposure is in the area south of Northing 25,500 and east of Easting 31,000 (see Chapter III, Map III-2). A north-south 2D slope stability section was generated along Easting 31,000. The results of the 2D slope stability analyses along this section resulted in a minimum factor of safety of 1.1. This minimum factor of safety was associated with a block slip failure surface along the uppermost Tbf layer, extending from directly beneath the southern part of the dump between Northings 28,000 to 29,000 to daylight at about Northing 25,200 (a total north-south distance of about 3,300 feet). This low factor of safety is associated with a highly localized critical failure mode. Stability analyses for nearby sections (within 200 feet of this section) indicated minimum factors of safety of 1.3 or greater.

A 3D slope stability analysis was done to confirm that the overall factor of safety for the hypothesized failure mode was 1.3 or greater. Three different cases of sliding were evaluated to analyze various critical conditions of dip direction, and daylighting of the potential slip surfaces. The critical dip and daylighting cases for potential 3D slip surfaces that were analyzed included:

- Case 1: Sliding south 20° west. Average case in terms of apparent dip angle in the sliding direction, and depths of breakthrough at the toe.
- Case 2: Sliding south 43° west. The apparent dip angle is maximized at 5.7°, but there is some passive resistance in the potential toeout area along the Sheep Rock Creek drainage where minimum depth of breakthrough of the overlying Tba of approximately 50 feet would be required.
- Case 3: Sliding south. This maximizes the impact of the daylighting condition, but the apparent dip angle is relatively small (average of 4.2°).

The factors of safety for these three cases and for the 2D analysis described above are summarized on Table IV-2.

Proposed Buttress

The outline of the proposed buttress is shown in Chapter III on Map III-3. The extent of this buttress also is shown on Cross-Section MPS in Chapter III on Figure III-4. The proposed buttress would improve to 1.3 the static factor of safety against further sliding of the Sunlight Block. This represents an additional 10 percent over the No Action Alternative margin of safety against future movement of the block slip.

The final, outer slopes of the proposed buttress would be reclaimed at 3:1 (horizontal:vertical). Mass slope stability concerns, and not reclamation criteria, control the 3:1 reclaimed slope inclinations for both the proposed buttress and south face of the East Waste Rock Dump. This was discussed under the No Action Alternative in Section IV.A.1.a. The need for the shallower slopes at these specific locations is attributed to their proximity and orientation with respect to known or potentially weak foundation materials. In the case of the proposed buttress, the foundation conditions are well understood on the basis of extensive site investigations and back-analyses for material strengths (Golder Associates Ltd. 1995h).

Pit Wall Expansion

Under the Proposed Action, the pit would be enlarged an additional 24 acres, to a total of approximately 336 acres. Consequently, the Proposed Action would result in additional exposed pit wall surface area, and a maximum pit wall height of 1,750 feet on the northwest wall of the pit, as compared to a maximum pit wall height of 1,375 feet under the No Action Alternative. The Proposed Action overall pit wall angles, bench widths, and bench slope angles are similar to those for the No Action Alternative. An exception to this is that the Proposed Action would eliminate the large benches at elevations 5,300 and 5,700 which are shown for the ultimate pit in the No Action Alternative.

The elevation of the pit lake is estimated to be 5,050 feet under the Proposed Action. The pit bottom would be deepened to approximately elevation 4,700 feet, such that the pit lake would be about 350 feet deep. The deeper pit, with higher pit walls, will be less stable than the No Action Alternative during operation. However, once operation ceases and the pit lake water level is allowed to rise to elevation 5,050 feet, stability of the pit walls will increase. This stability increase occurs because the water in the pit adds a stabilizing load to the toe of the pit wall slopes. Thus, the long-term stability of the Proposed Action pit walls will be greater than the short-term (during operation) stability. However, the pit wall stability under the Proposed Action will be reduced compared with the No Action Alternative because the overall height of the pit walls will be greater.

Environmental Consequences

As discussed for the No Action Alternative, adverse environmental consequences are linked to ground movement potential using FMEA which is provided in Appendix H.

Environmental consequences and likelihood categories that are related to ground movements under the Proposed Action are essentially unchanged from those described for the No Action Alternative for the following primary failure modes:

- Movement of the Sunlight or Rattlesnake Block Slips: The static factor of safety is improved from 1.2 to 1.3, but this does not substantially alter the environmental risks. Consequences associated with seismically induced movement of the Sunlight Block would be mitigated because the presence of the proposed buttress would reduce the magnitude of potential block displacement. Seismic analyses indicate that with the proposed buttress emplaced, the expected maximum movement at the margins of the Sunlight Block would be up to 4 feet, compared with up to 6 feet of localized movement with only the interim buttress. This restricted movement would mitigate the consequences associated with movement of the Sunlight Block, but not enough to change the level of environmental consequences or reduce the likelihood categories.

- Slope Failure on West Waste Rock Dump: Same as for the No Action Alternative.

- Slope Failure on Block Buttresses: The environmental consequences and failure mode likelihood categories for the enlarged proposed buttress are the same as for the interim buttress.

- Settlement of the Tailings Impoundment Covers: Conditions related to settlement of the reclamation cover for Tailings Impoundment No. 1 would be unchanged from the No Action Alternative. Because more tailings would be impounded in the Tailings Impoundment No. 2 facility under the Proposed Action, larger settlements may be expected compared to the No Action Alternative, but likelihood and environmental consequence level categories would not be changed.

- Failure of the Tailings Impoundment Dams: Although a larger volume of tailings materials would be involved in the failure scenarios, the consequence levels and likelihood categories are the same as for the No Action Alternative.

- Pit Wall Instability: Pit walls following mine reclamation would be left generally as shown in the Proposed Amendment. As for the No Action Alternative, it would be expected that some portions of the pit walls would be subject to raveling, talus formation, erosion, and limited rock mass movements, thus locally altering the configurations of some of the pit walls. In particular, rock mass movements may be expected along the northwest area of the pit, where the unfavorable orientation of existing faults renders this area less stable. As these mass movements occur, however, the overall stability of the pit walls would be expected to increase over the long-term as the rock and soil materials achieve a more stable configuration. The failure mode likelihood and environmental consequences categories would be unchanged from the No Action Alternative.

Earth movement FMEA results that differ from the analyses developed for the No Action Alternative relate to slope stability on the expanded East Waste Rock Dump and possible East Waste Rock Dump-triggered block slip movements east of the Sheep Rock Creek drainage. The FMEA indicate that the differences between these Alternatives are small with respect to potential ground-movement impacts to the environment. The likelihood of initiating a new east block slip is moderate, and appears to be the primary difference between these Alternatives. However, failure modes that are associated with East Waste Rock Dump-triggered block slip movements do not represent significantly greater risks to the environment. These risks appear to be mostly related to disruption of the reclamation cover on the expanded East Waste Rock Dump which has the consequence of exposing limited volumes of ARD-generating materials to surface infiltration. Mitigation Measure G-2 in Section IV.P, Potential Mitigation and Monitoring, addresses potential ground movements in the East Waste Rock Dump. More severe environmental consequences that are associated with East Waste Rock Dump-triggered block slip movement have very low to negligible likelihoods of occurring. Refer to the detailed FMEA in Appendix H for descriptions of these failure modes.

IV.A.2.b Paleontological Impacts Associated with Continuing Mining

Geologic maps of the Proposed Action area indicate that occurrences of the Bozeman Group geologic unit, which has been identified as containing significant vertebrate fossils at the mine and in other localities, are located in the proposed East Waste Rock Dump expansion area in Sections 20 and 21, in the proposed buttress expansion area in Section 26, and in portions of the Tailings Impoundment No. 2 expansion area in Section 28. Paleozoic-age alluvial and colluvial deposits, similar to those which have been associated with significant vertebrate fossil findings in the Sheep Rock area, also are located in the proposed East Waste Rock Dump expansion area, in the proposed buttress expansion area, and in portions of the tailings impoundment expansion areas. In total, about 99 percent of the 385-acre East Waste Rock Dump area proposed under this alternative lies in Bozeman Group or Pleistocene-age alluvial deposits. Site 24JF292, a significant Pleistocene-age paleontological and archaeological site located near Sheep Rock in Section 21, also lies adjacent to the proposed boundaries of the East Waste Rock Dump expansion area.

Implementation of the Proposed Action would not destroy any known fossil beds but could limit access to and restrict future study of the occurrences of the Bozeman Group and Paleozoic-age alluvial deposits. Previously unidentified paleontological resources could be encountered and/or directly impacted during the course of mine operations and reclamation. If significant fossiliferous deposits, specifically Tertiary vertebrate fossil deposits, are located during construction, operation, or reclamation of the mine under the Proposed Action, paleontologists from the appropriate state or federal agency should be immediately contacted and measures taken to identify and preserve the fossils (see Mitigation Measure P-1).

Potential indirect impacts could result from continued accessibility to fossil beds via improved transportation routes in the mine area and from continued increases in human activity in the area related to mine work. Portions of site 24JF292 could be indirectly affected by waste rock dump operations. However, GSM has committed to avoiding the site. Following mine closure, indirect impacts are expected to be slightly reduced with the decrease in human activity in the area.

IV.A.3 Return Diversion Alternative

IV.A.3.a Geologic Impacts Associated with the Return Diversion Alternative

The primary geologic/geotechnical concern associated with diverting Sheep Rock Creek is the potential for slope instability along the north or east segments of the East Waste Rock Dump. Slope failure could encroach upon or entirely block the diversion channel. Diverted water could potentially come in contact with waste materials for relatively long periods of time if the channel is fully blocked and storm water is trapped behind the dump. Uncontrolled runoff also could cause erosional problems along the waste rock dump toe or in undisturbed areas outside the disturbance boundaries.

The potential for slope failure along the north and east faces of this dump was not analyzed explicitly. The south face and southeast corner of the dump were evaluated, and the minimum factors of safety for as-built and reclaimed slopes at those locations are summarized on Table IV-2. Foundation conditions beneath the north and east portions of the east dump are more favorable than along the south portion. But because the Proposed Action would use 2:1 slope inclinations on the north and east sides of the dump and 3:1 slopes on the south face, it is not possible to conclude that the factors of safety of the north/east slopes are comparable or better than those analyzed. However, based upon analyses of other areas where 2:1 slopes are proposed, these slopes are expected to be stable.

The earth movement FMEA for the Return Diversion Alternative is identical with the analyses done for the Proposed Action, as summarized in Appendix H.

IV.A.3.b Paleontological Impacts Associated with the Return Diversion Alternative

Impacts to paleontological resources under this alternative would be the same as to those identified under the Proposed Action.

IV.A.4 Divided Dump Alternative

IV.A.4.a Geological Impacts Associated with the Divided Dump Alternative

The Divided Dump Alternative elements that would change ground movement potential in comparison with the Proposed Action Alternative are:

- Division of the East Waste Rock Dump to maintain the Sheep Rock Creek drainage feature; and
- Relocation of waste rock materials to alternative areas.

The Divided Dump Alternative requires that waste rock material, which would have been allocated primarily to the expanded East Waste Rock Dump in the Proposed Action, be relocated to alternative dump areas. The intent of this alternative is to avoid permanently blocking the Sheep Rock Creek drainage with mine waste. Alternative sites for waste disposal include Areas A, B1, B2, C1, and C2 as shown in Chapter II, on Map II-3. This alternative allows any combination of these sites to be used as needed to accommodate the waste material that would be generated under the Proposed Action.

Potential for Earth Movements

Elements of this alternative that would substantially change the potential for detrimental ground movement in comparison with the Proposed Action or No Action Alternatives are associated with waste rock placement at alternative dump sites. Potential for earth movements are discussed below in relation to the general locations of these sites: Area A (north), Areas B1 and B2 (east), and Areas C1 and C2 (west). Specific, detailed geotechnical site investigations for these areas, and slope stability analyses for the proposed dump configurations are not available. The following evaluations of the potential for earth movements in these areas are based on the available information and should be considered preliminary.

Area A. Alternate dump Area A is located north of the pit access road cut, at the mouth of the Midas drainage. The dump would be constructed as an northwest extension of a portion of the East Waste Rock Dump which has been historically referred to as the Midas Dump. The available space for waste storage in this area is constrained by topography on all sides: on the north by the natural rising ground surface, on the south and east by the existing waste rock dump, and on the southwest by the pit. Area A would add 5 million tons of waste rock and 3 new acres of disturbance to the East Waste Rock Dump.

The Area A dump could add more mass to a segment of the head area of a known landslide, the Midas Slump. This landslide feature is outlined in Chapter III, on Map III-3. The history of movement of this landslide is discussed in Section III.A.2.b, Ground Movements. Should this alternative dump location be selected, additional geotechnical site studies and analyses should be performed to address the following concerns:

- Investigate the possibility of triggering additional movement of the landslide known as the Midas Slump.
- If there is a potential for triggering movement of the Midas Slump, evaluate whether the consequences of this movement (e.g., down slope slumping of waste materials) could destabilize the Sunlight or Rattlesnake Blocks.
- Confirm the stability of the dump slopes and pit access road cut slope, taking into consideration their proximity.

Areas B1 and B2. Disposal Areas B1 and B2 are situated north and east of the site for the Proposed Action East Waste Rock Dump. These dumps would be founded on predominantly limestone bedrock. Dump material would be placed within deep swales along the northeastern bedrock ridge that forms the rim of the valley, adding 65 million tons of waste rock and 510 acres of new disturbed area. Placing waste rock on the bedrock ridge and out of the valley-fill sediments would provide more favorable foundation stability conditions. This alternative would eliminate the potential for mine dumping activities initiating block slip earth movements along weak bedding planes in the valley-fill sediments east of Sheep Rock Creek drainage.

There is little information available on the quality of the Paleozoic sedimentary bedrock in Areas B1 and B2. The geotechnical report on the East Waste Rock Dump stability (Golder Associates Ltd. 1995i) noted that the bedrock underlying the Proposed Action East Waste Rock Dump had been fractured, folded, faulted, and intruded by Cretaceous mafic sills. Prevailing strikes are northwesterly and dip steep (60°) to the northeast. The rock quality beneath a thin weathered zone was reported to be good to very good, with the weathered bedrock rated as moderate to good. Assuming the quality of rock in Areas B1 and B2 is comparable, it would provide a stable foundation for the waste rock dumps. However, the quality of the bedrock foundation needs to be verified through appropriate field investigations if this alternative is selected. Specific slope stability analyses for the proposed dump configurations also are required before a detailed evaluation can be done.

Areas C1 and C2. Alternate dump sites C1 and C2 would be extensions of the West Waste Rock Dump to the southwest and west, respectively (see Chapter II, Map II-4). These dump areas would add 50 million tons of waste rock and 390 acres of new disturbed area. Based on geologic mapping, the foundation conditions in these areas are likely similar to the conditions described for the Interim West Waste Rock Dump. Geotechnical analyses for the Interim West Waste Rock Dump indicate that it is founded on a thin veneer of gravelly soil overlying sedimentary bedrock (sandstone, siltstone, and shale) (Golder Associates Ltd. 1995b). The bedrock is highly fractured and folded. Folding has caused local variations in bedding orientation, especially under area C2. Considering the nonuniform bedding orientation and the well-lithified (hardened into rock) nature of the bedrock, it is likely that any slope failure surfaces would be constrained within the surficial gravelly soils and waste materials above the bedrock. These materials generally have high shear strengths, and stability analyses will probably indicate that 2H:1V slopes will be stable.

However, specific geotechnical data are lacking in the areas of the C1 and C2 dump foundations. Specific geotechnical site investigations and slope stability analysis would be required to confirm the foundation conditions and mass slope stability of the proposed C1 and C2 dump configurations, if this alternative were selected.

Environmental Consequences

Environmental consequences and likelihood categories that are related to ground movements under the Divided Dump Alternative are essentially unchanged from those described for the No Action Alternative for the following primary failure modes:

- Movement of the Sunlight Block;
- Slope Failure on the Interim East Waste Rock Dump;
- Slope Failure on the West Waste Rock Dump;
- Slope Failure on Block Buttresses;
- Settlement of the Tailings Impoundment Covers;
- Failure of the Tailings Impoundment Dams; and
- Pit Wall Instability.

Earth movement FMEA results that differ from the analyses developed for the No Action Alternative relate to slope stability on the Alternative Dump Sites.

The most apparent differences between the Proposed Action and the Divided Dump Alternatives are the increased number of low likelihood environmental consequences, and the slightly reduced number of moderate likelihood consequences. These differences are not substantial or significant, and appear to indicate that there is little difference in environmental risk between the Proposed Action and the Divided Dump Alternatives with respect to ground movements.

IV.A.4.b *Paleontological Impacts Associated with the Divided Dump Alternative*

Impacts to paleontological resources under the Divided Dump Alternative would vary depending upon the alternative dump locations chosen. Differences in impacts to paleontological resources by alternative dump location are identified below. Effects to potentially significant deposits in other areas of the mine, including the tailings impoundment and buttress areas, would be identical to those described under the Proposed Action.

Area A:	Direct impacts to potentially significant paleontological deposits in Bozeman Group and Pleistocene-age alluvial units would be minimal in Area A. No Bozeman Group or other Tertiary-age units have been identified in the dump area, and approximately 30 percent or less of the dump's 30-acre area is located in Pleistocene-age alluvial deposits.
Area B1:	Approximately 50 percent of the surface area covered by Area B1 lies on Bozeman Group or Pleistocene-age alluvial deposits. These areas would be buried if Area B1 is selected.
Area B2:	Approximately 25 percent or less of the surface area covered by Area B2 lies within Bozeman Group or Pleistocene-age alluvial deposit areas. These would be buried if Area B2 is selected.

Area C1: No Bozeman Group formations have been identified in the area covered by Area C1. Less than approximately 5 percent of the surface area covered by the dump lies in Pleistocene-age alluvial deposits.

Area C2: No Bozeman Group formations have been identified in the area covered by Area C2. Less than approximately 5 percent of the dump lie in Pleistocene alluvial deposits.

IV.A.5 3:1 Slope Alternative

IV.A.5.a Geological Impacts Associated with the 3:1 Slope Alternative

Waste rock dump slopes that are reclaimed at 3:1 would be inherently more stable than the same slopes reclaimed at 2:1, in terms of mass slope stability. Rigorous analyses for 3:1 slope inclinations were not performed except for those slopes that are presented as such for the Proposed Action. The proposed buttress and the south face of the East Waste Rock Dump slopes would be reclaimed at 3:1 under the Proposed Action. Factors of safety for those slopes are presented on Table IV-2 in Section IV.A.2.a.

The earth movement FMEA for the 3:1 Slope Alternative is identical with the analyses done for the Proposed Action, as summarized in Appendix H. Although factors of safety would be higher for 3:1 versus 2:1 slopes, the improved waste rock dump slope stability would not substantially change the failure mode likelihood categories for the West Waste Rock Dump, the Block Buttresses, or the expanded East Waste Rock Dump.

Additional acreage would be disturbed by reducing the slope angles. An additional 125 acres would be covered by materials capable of generating ARD in comparison with the Proposed Action Alternative.

IV.A.5.b Paleontological Impacts Associated with the 3:1 Slope Alternative

Impacts under the 3:1 Slope Alternative would be the same as those identified under the Proposed Action, except that access to approximately 20 more acres of Bozeman Group and Paleozoic-age alluvial deposit surface appearances could be restricted. The additional acres would be buried in the East Waste Rock Dump expansion area under this alternative.

IV.A.6 No Pit Pond Alternative

IV.A.6.a Geological Impacts Associated with the No Pit Pond Alternative

Exposed reduced or sulfide-rich wall rock in the pit would continue to oxidize through percolation and infiltration of precipitation and spring seeps regardless of the effectiveness of dewatering. The oxidation and replacement of iron oxyhydroxal complexes may locally have impact on wallrock stability and in some instances actually enhance stability through iron carbonate cements. Excessive acidity produced with the degradation of sulfides may locally degrade the integrity of felsic rocks causing exfoliation and crumbling on exposed surfaces. However, dewatering should generally limit the rate and uniformity of this rock degradation process.

Current pit high walls slopes average 61° between the benches. As the pit expands and deepens, the high wall slope may locally increase as deeper ore zones are pursued. Water as a buttress for the lower 100 feet of the pit would not be available under this alternative. The overall pit wall height of this alternative will be 100 feet less than for the Proposed Action. However, the benefit of the lower overall wall height will be offset by the lack of a pit lake, which provides stability to the lower portions of the slopes. Generally, stability under this Alternative would be expected to be similar to the Proposed Action, but less than for the No Action Alternative. Post-closure stability of high walls in a perpetually dewatered pit would greatly depend upon wallrock integrity. Seeping and fractured areas would generally tend to be less stable unless secondary processes cause cementation of the materials in such zones.

Pit wall slopes would continue to undergo alternating periods of rock sloughing and quiescence for years after mining has ceased. As the pit walls are acted on by gravity and the rock fracturing forces of freeze-thaw cycles, the near-vertical pit walls would ultimately shed material to form talus slopes at their base, trending to ever decreasing vertical walls at the higher elevations. This natural process would take longer to achieve a state of pit slope equilibrium owing to the taller pit walls proposed under this alternative. Unless triggered by severe tectonic activity, the pit walls should achieve a post closure equilibrium in 10 years or less, with further minor adjustments in excessively wet or high freeze-thaw event years and in years with earthquakes.

Earth movement FMEA results for this alternative are identical to the Proposed Action analysis, as summarized in Appendix H.

IV.A.6.b Paleontological Impacts Associated with the No Pit Pond Alternative

Impacts to paleontological resources under this alternative would be the same as those identified for the Proposed Action.

IV.A.7 Partial Backfill Alternative

IV.A.7.a Geological Impacts Associated with the Partial Backfill Alternative

Under this alternative, approximately 250 acres of the pit walls and floor would be capped with oxide rock and soil and then revegetated. All acid producing rock within the pit would be capped. Rock backfill would initially be hauled from the East Waste Rock Dump and end-dumped from the benches above. Material from the West Waste Rock Dump areas would then be end-dumped from the pit crest to complete the backfilling.

Backfilling the pit and partially capping the pit walls under this alternative would aid in decreasing the amount of pit wall sloughing over time and facilitate pit wall equilibrium sooner than otherwise would be realized under all but the No Action Alternative.

The earth movement FMEA results for this alternative are identical with the Proposed Action except for the Pit Wall Instability failure mode. The FMEA, as summarized in Appendix H, indicates that there is no substantial difference in overall environmental risk between this alternative and the Proposed Action Alternative, with respect to potential ground movements. Mitigation Measure G-5 was developed to address potential impacts related to worker safety and stable cover of pit wall surfaces.

IV.A.7.b Paleontological Impacts Associated with the Partial Backfill Alternative

Impacts to paleontological resources associated with this alternative would be the same as those identified for the Proposed Action.

IV.B WATER RESOURCES

IV.B.1 No Action Alternative

IV.B.1.a Waste Rock Dumps

Waste Rock Impacts to Water Quality During Mining Operations

Geochemical testing data for the waste rock generated at Golden Sunlight Mine indicate that the majority of waste rock materials are potentially acid generating. Factors governing the formation of ARD within the waste rock dumps are discussed in Appendix I. Operational impacts to water quality associated with waste rock dumps under this alternative are tied to the exposure of reactive sulfide minerals in waste rock to weathering conditions prior to reclamation. The reclamation plan calls for reclamation caps to limit the infiltration of direct precipitation into waste rock dumps. During the time prior to installation of the caps, infiltration will exceed estimates for the long-term infiltration rate. The operational period, however, represents a very small portion of the long time spans that are predicted before any ARD impacts could be observed (on the order of hundreds to thousands of years). The analyses suggest there would be no impacts during active mining.

Active areas of waste rock dumps are potentially subject to infiltration and surface erosion by storm runoff flows. Dump areas are protected from rainfall or snowmelt runon by surface water diversion structures, such as berms and ditches. Runon control features are designed to divert flows away from waste rock areas. Surface water diversions for the No Action Alternative are presented in Map IV-1. The only significant surface water flows that can contribute to infiltration and erosion during operations are the result of precipitation which falls directly on the waste rock dump surfaces. However, field data collected during mine operations to date indicate that infiltration is not occurring at a rate sufficient to saturate materials on the interior of the dumps. Consequently, no ARD associated with infiltration of active dumps is anticipated.

Some ARD from active dumps could occur as surface runoff. The extent to which this could occur is dependent on the magnitude of the storm event. ARD on waste rock dump surfaces is commonly noted where precipitation runoff water accumulates on the dump surfaces following runoff events. Byproducts of ARD reactions also are common on acid-producing waste rock surfaces that have been wetted and subsequently dried. Runoff water from the waste rock dumps, if it ever occurs, typically carries this surface accumulation of salts that have precipitated from the ARD reactions. The time interval for contact between ARD-generating materials and storm runoff is not expected to be extensive and the production of ARD by this mechanism will be negligible. Runoff from active waste rock dumps is generally contained by detention berms constructed at the toe of the waste rock dumps. Any ARD reporting to the detention berms will contact colluvial materials which flank Bull Mountain and will flow a very short distance across the surface before infiltrating. The colluvial material into which ARD might infiltrate has some capacity to neutralize and attenuate the migration of contaminants to groundwater. Consequently, ARD impacts associated with surface runoff from active dumps are unlikely.

Storm water, including surface runoff from dumps, has been reported to the state as showing no ARD impact. Surface runoff from dumps is limited as much as possible, as described above. To date, monitoring wells downgradient of active dumps show no ARD impacts.

Waste Rock Impacts to Long-Term Water Quality

Under the No Action Alternative, long-term impacts to groundwater quality in the vicinity of the waste rock dumps would likely occur because of gradual ARD from the waste rock dumps. Impacts would be minimized by upslope runon diversions, and the reclamation caps (GSM 1995a). To address potential impacts downgradient from the waste rock dumps, GSM has applied to the state of Montana for a "mixing zone" (see Appendix B) that would allow some degradation of water

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quality within its proposed boundaries. The mixing zone proposed by GSM would extend to GSM's existing permit boundary to the north, east, and southeast of the mine; and approximately 0.5 beyond GSM's existing permit boundary to the west and southwest of the mine (see Figure 5-1 in Appendix B).

ARD fate and transport analyses (see Appendix J) indicate that full chemical neutralization of ARD from the East Waste Rock Dump will likely occur within 2,200 to 4,400 feet downgradient from the toe of the dump because of the neutralizing characteristics of the aquifer materials and dilution. Thus, natural neutralization of East Waste Rock Dump ARD is expected to occur within GSM's proposed mixing zone limits (see Figure 5-1 in Appendix B).

Because of the different hydrogeologic conditions on the west side of the mine, natural neutralization of ARD from the West Waste Rock Dump is anticipated to be minimal (attributed to dilution only). Long-term monitoring and implementation of groundwater protection measures for ARD seepage from the West Waste Rock Dump are described in GSM's Long-Term Water Management Plan (see Appendix A). The analyses provided in Appendix B indicate that with an efficient West Waste Rock Dump groundwater capture system, which is part of GSM's Water Management Plan, ARD impacts can be contained within the mixing zone limits that have been proposed by GSM (see Figure 5-1 in Appendix B). The evaluation presented in Appendix L indicates it is technically feasible to install an efficient groundwater capture system for the West Waste Rock Dump, provided adequate site characterization is done to identify preferential flow paths in bedrock fracture zones, and/or conservative capture well spacings are used to ensure that all major fracture zones are intersected by at least one well.

Estimation of Long-Term ARD Production by Waste Rock Dumps. The long-term quality of discharge from the toe or base of a waste rock dump is controlled by the flow of water through the dump materials, the availability of oxygen, and the abundance of sulfide minerals in the waste rock (see Appendix I). The existing reclamation plan provides for capping of all waste rock dump surfaces with 24 inches of oxide or neutral rock having a NAG pH greater than 4, plus a cover-soil that will be revegetated. The cover-soil will be 19 inches on the West Waste Rock Dump, and 24 inches on the East Waste Rock Dump. The grain size of the soil is anticipated to have a higher water retention capacity than the oxide waste rock and is expected to minimize infiltration which falls on the dump in the form of direct precipitation (either rain or snow). Revegetation of the surface will provide additional water consumption. The reclamation cover is designed to limit water infiltration, thus minimizing the migration of ARD through the interior of the waste rock dumps.

Research at other sites indicates waste rock dump capping greatly reduces infiltration and reduces the potential for experiencing an initial, very concentrated spike or peak of ARD discharge that is substantially more concentrated than the long-term average. The reduction or elimination of the initial spike effect from waste rock dumps minimizes impacts by avoiding extreme short-term ARD loading (the amount of ARD released per unit time) to the local groundwater and surface water environment. Thus, capping measures aimed at reducing water infiltration rates will reduce pollutant load in the short-term. However, based on the results from long-term ARD studies conducted at other sites, ARD load could return to a value dictated by the overall oxidation rate in the long-term (Harries and Ritchie 1987; Harries and Ritchie 1985; Bell et al. 1994; Trembley 1994). These studies indicate that the long-term load exiting the base of the waste rock dumps may be independent of the rate at which water infiltrates the dump, and that for a range of potential infiltration rates the long-term ARD load would be expected to be similar.

At Golden Sunlight Mine, three modeling approaches were used to provide an assessment of the water balance within reclaimed dumps:

- Hydraulic Evaluation Performance (HELP; Schroeder et al. 1994);
- An in-house model of Schafer and Associates (consultants to GSM); and
- SOILCOVER (Swanson 1995).

These models use soil, climatic, vegetative, and design information to establish a water budget. A variety of parameters are considered in each model such as average precipitation, leaf area, porosity, etc., that address the manner in which water on the dump surface can be removed by evaporation, evapotranspiration, and runoff. The difference between these removal mechanisms for water and the incident precipitation is the quantity of water which is estimated to enter the dump interior by percolation.

All three model calculations are in general agreement and suggest that infiltration through the reclaimed dump surface would be on the order of 0.25 inch per year, which is only about 1.7 percent of the approximately 14 inches of precipitation incident to the dump surface area. The infiltration might be as high as 0.5 inch in wet years. Seepage from waste rock dumps for the 0.25 inch infiltration is estimated to ultimately be about 10 gpm, or 2.2 million gallons per year as the total contribution from all waste rock areas.

For reclaimed sites, water balance models suggest that little difference in infiltration should be observed for 3:1 versus 2:1 slopes. Thus, regrading slopes to 3:1 would appear to offer no significant infiltration difference from 2:1 slope inclinations.

Estimation of Long-Term Fate and Transport of Waste Rock ARD. A numerical simulation was performed by the EIS review team to assess the ultimate extent and timing of ARD impacts (see Appendix J). A hydrogeochemical model was developed for the EIS to estimate the types of impacts to water quality that potentially could be caused by ARD from the waste rock dumps. The model simplifies very complex hydrogeological and geochemical processes. Consequently, there will likely be some degree of error within the model predictions due to uncertainty in the model input parameters. The model was intended to characterize the types of possible impacts, not to accurately quantify those impacts. These impacts may or may not occur depending on future site-specific conditions such as long-term climatic conditions, infiltration rates, and oxidation rates, in addition to other physical conditions which are difficult to quantify such as moisture migration pathways, rate of groundwater movement and flow paths, and subsurface geochemical conditions. Also, the potential impacts were evaluated only for the Bozeman hydrostratigraphic unit on the east side of the Golden Sunlight Mine site, and for the bedrock hydrostratigraphic unit on the west side of the site. This groundwater will join and mix with neutralizing groundwater within the high permeability gravels of the Jefferson alluvial groundwater system before mixing with surface water.

The results of the model indicate that potential impacts to groundwater range from being negligible on the east side of Bull Mountain, to experiencing elevated levels of sulfate and trace metals on the west side of Bull Mountain. The time to potential impact could be several tens of years following closure to several thousands of years. The degree of impact will be a function of distance away from the waste rock dumps.

The model evaluated ARD fate and transport times for three different dump precipitation infiltration scenarios, as follows:

- Best-Case (least dump infiltration, 0.25 inch per year);
- Worst-Case (highest estimated dump infiltration, 2 inches per year); and
- Expected Case (expected dump infiltration, 0.5 inch per year).

As mentioned above, the accuracy of the fate and transport model is limited by its inherent assumptions. Some of the assumptions used in the model included:

1. Time interval required for waste rock dumps to wet sufficiently under the applied

infiltration rates for downward seepage to begin.

2. Time interval for seepage to infiltrate the thick unsaturated (vadose) zone extending from the base of the waste rock dumps to the water table.

3. Geometry (width and depth) of the anticipated groundwater flow path (modeled as a "wedge" that thickens downgradient from the waste rock dumps to simulate dilution effects).

4. Amount of neutralizing minerals (calcite) in the aquifer solids (estimated to be approximately 5 percent on the east side of Bull Mountain, and zero on the west side).

5. Concentration of ARD solutions emerging from the waste rock dumps (estimated based on present measurements within the reclaimed dumps).

6. Lifetime of ARD production in the waste rock dumps (which depends, in part, on the assumed infiltration rate and the total volume of sulfide minerals in the dumps).

Some of these assumptions were developed using site-specific field data and observations. Other assumptions were based on professional judgement. Model inputs were selected to be consistent with available data (e.g., for dump and vadose zone material hydraulic characteristics). Uncertainties regarding the model inputs and the simulation itself allow for only a low to moderate level of confidence in the model predictions of specific ARD concentrations and travel times to various locations downgradient of the waste rock dumps.

Maximum concentrations of select trace metals in groundwater immediately downgradient of the dumps were estimated using simple relationships to correlate metal concentrations with the sulfate concentrations that were predicted by the mixing cell model. These correlations were developed in part based on column studies of ARD attenuation by Bozeman Group aquifer materials (Schafer and Associates 1994). The influent water quality (simulated ARD) used in the column studies is summarized in Appendix B. Concentrations of select trace metals arsenic (As), cadmium (Cd), copper (Cu), manganese (Mn), and zinc (Zn) in the simulated ARD are summarized on Table IV-3. For comparison, actual measured concentrations of these metals in waste dump pore water also are provided on Table IV-3. It can be seen that the metal concentrations in simulated ARD generally were much higher than have been observed in dump pore water. The column study results should therefore provide a conservative basis for the sulfate-metals concentration correlations used in these estimates.

The estimated maximum ranges of future metal concentrations in groundwater are summarized on Table IV-3. Future metal concentrations in groundwater are predicted to range anywhere from background (current ambient concentrations) to maximum values that were estimated from the mixing cell model predicted sulfate concentrations. Sulfate concentrations with time and distance from the East and West Waste Rock Dumps are plotted in Appendix J. Only the maximum (peak) sulfate concentrations predicted for maximum infiltration rates were used to estimate the maximum metals concentrations. These concentration estimates are intended only to provide a gross sense of the possible range of maximum impact that could occur, and are subject to the same uncertainties previously described for the mixing cell model itself.

In Table IV-3, "BG" indicates background concentration as a possible lower limit. Actual background concentrations of dissolved trace metals in the groundwater at the mine site are provided in a database maintained by mine staff and in the records provided to the Montana DEQ (GSM 1995a, 1995c, 1996a). A general summary description of the background water quality is provided in Section III.B.2, Groundwater Resources. In general, dissolved metals in groundwater are at or below detectable concentrations in the Bozeman aquifer in the vicinity of the East Waste Rock Dump. The exception on the east side is in the vicinity of Rattlesnake Gulch, where relatively

Table IV-3

Summary of Background Water Quality and Waste Rock Dump ARD-Associated Metals Concentrations

Water Quality Source	Concentration (mg/L)				
	As	Cd	Cu	Mn	Zn
Geometric Mean - Existing Dump Pore Water Quality[1]	0.047	0.048	9.2	6.6	2.7
Simulated ARD from Waste Rock Dumps - Column Studies[2]	10	0.6	380	134	130
Predicted Maximum Range in Groundwater - East Side[3]	BG[8]-2.0	BG-0.2	BG-100	BG-80	BG-43
Predicted Maximum Range in Groundwater - West Side[3]	BG-2.0	BG-0.15	BG-105	BG-55	BG-28
BG Geometric Mean East Side Rattlesnake Gulch[4]	0.005	0.0036	0.434	0.681	0.542
BG Geometric Mean East Side[4]	0.015	0.0012	0.007	0.029	0.052
BG Geometric Mean West Side West Flank[5]	0.007	0.002	0.01	1.85	0.458
BG Geometric Mean West Side East Flank[6]	0.0068	0.025	0.108	13.8	8.99
Montana Standards[7]	0.018	0.005	1.0	0.05	5.0

[1] Appendix B, Table 2-1.

[2] Schafer and Associates (1994).

[3] Appendix J, Table J-5.

[4] Appendix B, Table 4-1.

[5] Appendix B, Table 4-2.

[6] Appendix B, Table 4-3.

[7] Montana Numeric Water Quality Standards, August 3, 1995 (Circular WQB-7).

[8] BG = background (ambient) concentration.

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poor groundwater and spring water quality are indicative of localized mineralized zones in that area. On the west side, ambient concentrations of dissolved metals in groundwater are highly variable. Concentrations are naturally very high in mineralized zones, and frequently exceed established drinking water limits. In contrast, metals concentrations appear to be much lower in Bull Mountain bedrock zones that are not highly mineralized.

Appendix B includes summary tables of the ambient groundwater quality data, and statistical relationships for various groundwater regions that have been delineated for the site for purposes of impact analyses. The geometric means for these data are summarized on Table IV-3 for select trace metal background concentrations for the following areas: the Rattlesnake Gulch area and the area further east downgradient from the East Waste Rock Dump, and the west and east flank areas downgradient of the West Waste Rock Dump. (These areas are delineated on Figure 3-1 in Appendix B.)

The analyses presented in Appendix J provide a means to estimate the time interval before any waste rock-associated ARD impacts will occur. In the simple model, it is assumed that at first a "wetting requirement" must be satisfied; that is, the moisture that first infiltrates the initially very dry waste rock materials will be accumulated and held within the dumps until a minimum threshhold moisture is achieved. Once enough water has infiltrated the waste rock materials to have satisfied this wetting requirement, it is assumed that steady downward moisture flow can commence. The time required for the wetting requirement to be satisfied for an assumed average dump height of 300 feet, ranges from about 50 years under the worst-case infiltration assumptions to about 400 years for the best case assumptions. Under the expected net infiltration rate of 0.5 inch per year, an estimated 200 years is required for the full wetting requirement to be satisfied. Considering the variability in dump dimensions and textural characteristics, and the likelihood that preferential flow paths may be present, the time frame before any significant waste rock ARD seepage begins to occur from the base of the dumps ranges from tens to hundreds of years.

West Waste Rock Dump impacts will likely begin to occur shortly after the wetting requirement is satisfied. However, the mixing cell model predicts additional time will be required to develop maximum sulfate concentrations in the groundwater. Under the worst-case infiltration scenario, an estimated 750 years is required before the metals concentrations reach the maximum values indicated on Table IV-3.

East Waste Rock Dump impacts will occur much more slowly than on the west side because in addition to the wetting requirement, the ARD seepage also must travel through a thick (200 feet average) layer of unsaturated sediments under the dump before it reaches the Bozeman aquifer. Metal attenuation will occur as ARD seeps through the unsaturated zone, but this was conservatively neglected in the mixing cell model. Once the fully concentrated ARD eventually reaches the aquifer, the model accounts for both dilution and neutralization by natural calcite that is present in the Bozeman groundwater. Immediately under the dump, and for some distance downgradient, the model predicts that calcite will eventually be "used up" and the dilution will not be sufficient to prevent sulfate concentrations from increasing. The model predicts that, for the worst-case infiltration assumption, the maximum metals concentrations shown on Table IV-3 will be reached in about 1,200 years in groundwater immediately under the dump. However, within about 2,200 to 4,400 feet downgradient of the toe of the East Waste Rock Dump, there is sufficient dilution and calcite in the aquifer to neutralize waste rock-associated ARD impacts until the source is fully depleted.

A low to moderate level of confidence should be applied to these quantitative estimates of ARD concentrations and transport time frames. However, the results of the mixing cell model do allow the following general, qualitative conclusions to be made with a reasonable level of confidence:

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- The level of ARD impact is proportional to distance from the dumps: locations further from the dumps experience lesser impacts due to the combined effects of neutralization by naturally occurring minerals and dilution in the aquifer.

- The ARD impacts on groundwater for the Best, Worst, and Expected infiltration cases are not substantially different. The differences in peak concentrations and travel time predictions are not considered to be significant within the range of precision of the simulation itself.

- For the east side of Bull Mountain, impacts to groundwater may not appear for hundreds to thousands of years. Worst-Case infiltration rates cause more severe impacts (higher ARD concentrations) to occur sooner, but the impacts will last for a shorter duration in comparison with Expected or Best-Case assumptions. Modeling results indicate that, for all infiltration scenarios, essentially full neutralization of ARD will occur within a distance of about 2,200 to 4,400 feet downgradient from the East Waste Rock Dump, and that there will be no impacts to the Jefferson River alluvial aquifer at any future time. There appears to be sufficient neutralization capacity to offset any acidic input from the East Waste Rock Dump (i.e., no pH drop), consequently, increases in trace metals at the proposed mixing zone boundary on the east side of the mine site are considered unlikely.

- For the west side of Bull Mountain, there is little or no neutralization capacity in the west side bedrock unit to offset the potential input of ARD from waste rock dumps. Therefore low pH, high sulfate, and high metal concentrations may persist in groundwater within the bedrock unit in the vicinity of the West Waste Rock Dump.

The Water Management Plan presented in Appendix A provides for long-term groundwater monitoring, implementation of an appropriate groundwater capture system, and long-term treatment of any ARD from the West Waste Rock Dump. The capture system will probably comprise wells completed in the bedrock fracture zones which are the dominant groundwater flow paths on the west side. The analyses provided in Appendix L show that efficient (up to 100 percent) capture is technically feasible under these geologic conditions provided the wells intersect all the downgradient bedrock fracture zones. However, capture efficiency is reduced if any significant fracture zones are missed by the well system. Depending on the assumed relative hydraulic conductivities of the fractured versus unfractured flow area, capture efficiencies may range from approximately 94 percent to as low as 80 percent for a single missed fracture zone under the geometric assumptions made in Appendix L. It is critical that the spacing of the interception wells be frequent enough to intercept the preferential flow paths. A well spacing of 100 feet is recommended (see Appendix L). However, careful geologic exploration will need to be done to map fractures in the vicinity and to establish the optimal well spacing necessary to prevent impacts (see Mitigation Measure W-10).

Under expected infiltration rates of approximately 0.5 inch per year, high capture efficiency (up to 93 percent) will be needed to bring ARD concentrations low enough to meet Montana water quality standards at GSM's proposed mixing zone boundary (see Appendix B). However, it is likely that at least some of the total ARD will emerge as seeps from the dump toes, where it becomes "perched" on the bedrock surface and does not infiltrate to the bedrock aquifer. This phenomenon has been observed to occur prior to mining as natural seeps in the area, which are described in Section III.B.2.d in Chapter III. The analyses provided in Appendix B show that if half of the ARD is captured by shallow toe drains, the capture well system would need to be only 85 percent efficient in order to meet water quality standards at the property line. As discussed previously, these ranges of capture efficiency (85 to 93 percent) are considered to be technically achievable, and if correctly implemented, the groundwater capture and treatment system will prevent waste dump ARD impacts to groundwater or surface water outside of GSM's proposed mining zone boundary.

Waste Rock ARD Impacts to Beneficial Uses Under the No Action Alternative. The Montana Water Quality Act defines impacts to "Beneficial Uses" as impacts to public water supplies, wildlife, fish and aquatic life, agriculture, industry, livestock, and recreation. Known beneficial uses in the vicinity of the Golden Sunlight Mine are shown on Map IV-2. There are no public water sources within reasonable proximity that are downgradient of the East and West Waste Rock Dumps. Domestic wells are located in areas near the toe of Bull Mountain, approximately 6,500 feet downgradient from the closest waste dump (the West Waste Rock Dump), and approximately 4,000 feet downgradient from Tailings Impoundment No. 2. The nearest downgradient surface water fishery is the Jefferson Slough. There are no active agricultural uses within the mine's permitted area. Acreage adjacent to the Jefferson Slough is currently being cultivated. There are no known industrial uses (outside of the existing mine operations), or recreational beneficial use of the water resource that would be impacted by ARD from the waste rock dumps.

Because of the limited surface water availability, springs at the mine site are an important water source for local wildlife. Steppan and Steppan Original Springs are located immediately downgradient of the West Waste Rock Dump along the very southern edge. These springs are located within the boundary of the mixing zone proposed by GSM (see Figure 5-1 in Appendix B), and therefore have a high likelihood to be impacted by long-term ARD from the West Waste Rock Dump. However, the ambient water quality of the Steppan Spring is generally poor (i.e., low pH, high concentrations of metals) and incremental impacts attributable to ARD are not considered significant. Steppan Original Spring has a more neutral pH and therefore a reduction in water quality could impact the use of the Steppan Original Spring by wildlife.

An unnamed spring is located in a tributary drainage of St. Paul Gulch west of the West Waste Rock Dump (Map IV-2). This spring is located outside GSM's permit boundary and is not regularly monitored by GSM. It is likely a wildlife beneficial use, although the ambient water quality of the spring is unknown. Because this spring lies downgradient of the West Waste Rock Dump, and within the proposed mixing zone limits, it also has a high likelihood to be impacted by long-term ARD from the dump.

Rattlesnake Spring is located approximately 3,100 feet downgradient of the East Waste Rock Dump and is believed to receive flow from the Bozeman Unit aquifer. Bunkhouse Spring is approximately 3,400 feet downgradient of the East Waste Rock Dump and occurs within debris flow material. Because these springs are used by wildlife for watering, impacts to wildlife associated with reduced water quality could occur. Impacts are less likely to occur in the Rattlesnake Spring, because of the strong ARD attenuation effects that are anticipated in the Bozeman aquifer.

Sheep Rock Spring and Beaver Spring are used for livestock watering. These springs are located upgradient of the waste rock dumps. Consequently, no potential impacts from ARD to these springs is anticipated.

In summary, beneficial uses that could be impacted by ARD migration downgradient of the waste rock dumps, within the limits of the proposed mixing zone, include the Steppan Original, Bunkhouse, and Rattlesnake Springs, which are wildlife use areas; and an unnamed spring in the St. Paul Gulch drainage that may be a wildlife use area. Impacts to the Rattlesnake Springs are expected to be minimal because of ARD attenuation in the Bozeman aquifer. Adverse impacts to other beneficial uses are not anticipated. Mitigation of impacts to beneficial uses (namely, springs used by wildlife) within the mixing zone boundaries are described in Section IV.P, Potential Mitigation and Monitoring, Measure W-1.

It is anticipated that GSM's proposed groundwater capture system (see Appendix B) would be installed in fairly close proximity to the toe of the West Waste Rock Dump to minimize

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potential ARD impacts to beneficial uses. However, the capture system itself could impact beneficial uses downgradient of the well lines by the overall drawdown that would be imposed to maintain high-efficiency capture of ARD plumes. Impacts of the capture system drawdown are described in the following paragraphs.

Domestic wells, located approximately 6,500 feet downgradient from the toe of the West Waste Rock Dump, are far enough away that impacts from the groundwater capture system are unlikely. The nearest downgradient surface water fishery is the Jefferson Slough. Intercepted groundwater from the proposed capture system is to be routed to a permanent water treatment plant and eventually will report to the Jefferson Slough. Consequently no adverse impacts are anticipated to fish and aquatic life from the proposed capture system. Acreage adjacent to the Jefferson Slough is currently being cultivated. However, no adverse impacts are anticipated for these areas on the same basis as discussed for impacts to fish and aquatic life. There are no known industrial or recreational beneficial uses of the water resource (outside of the existing GSM operations) that would be impacted by the waste rock groundwater capture system.

Steppan, Steppan Original Springs, and the unnamed spring in St. Paul Gulch are all located immediately downgradient of the West Waste Rock Dump. Because of their proximity and downgradient location, these springs have a strong potential to be impacted by the West Waste Rock Dump groundwater capture system. However, the water quality of the Steppan Spring is generally poor (i.e., low pH, high concentrations of metals) and therefore any reductions in flow will not impact wildlife. Steppan Original Spring has a more neutral pH and therefore a reduction in flows could impact the use of the Steppan Original Spring by wildlife. The water quality in the unnamed spring is unknown, but it is likely that capture drawdown could impact its use by wildlife.

Potential impacts from the groundwater capture system on Sheep Rock Spring and Beaver Spring would be minimal because these springs are located upgradient of the waste rock dumps.

In summary, the proposed West Waste Rock Dump groundwater capture system is anticipated to maintain groundwater quality within Montana numeric Water Quality Standards within the mixing zone boundary that has been proposed by GSM (see Figure 5-1 in Appendix B). However, existing springs within the mixing zone may be impacted by ARD, and the capture system itself could result in impacts to wildlife in the form of reduced spring flows. Adverse impacts to other beneficial uses are not anticipated. Mitigation of impacts associated with ARD within the mixing zone, and capture drawdown are described Section IV.P, Potential Mitigation and Monitoring, Measures W-1 and W-5, respectively.

Long-Term Monitoring and Mitigation for Unanticipated Waste Rock ARD. It is possible that ARD-contaminated groundwater could bypass the proposed capture well system along shallow perched flow paths around the peripheries of the West Waste Rock Dump, or could travel through high conductivity preferential flow paths downgradient from the East Waste Rock Dump. In addition, the water infiltration rate through the waste rock dumps could be higher than estimated, resulting in a greater flow rate of ARD than anticipated. As a contingency, potential monitoring and mitigation measures to control and contain unanticipated waste rock ARD in groundwater under the No Action Alternative are presented in Section IV.P, Potential Mitigation and Monitoring, Measure W-4.

Waste Rock Impacts to Water Quantity

Water is consumed geochemically during the oxidation of sulfide minerals in the waste dumps. Additionally, the oxidation of sulfide minerals raises the internal temperature of the dumps and appears to produce a chimney-like effect where cool air is drawn in the sides of the waste rock dumps and hotter, moister air exits through the top. This effect ensures a continued supply of oxygen for sulfide mineral oxidation, but also can act to remove water from the dump interior in the form of water vapor. At the Golden Sunlight Mine, as much as 5 inches of water per year are reported to be removed by this convective mechanism at present, through steam vents observed on the surface of the dumps.

It is possible to estimate the rate at which pyrite and other sulfide minerals are oxidizing by monitoring the internal temperature of the dump (Harries and Ritchie 1987). The unreclaimed waste rock dump monitored by GSM appears to have a somewhat higher average temperature than reclaimed sites (Schafer and Associates 1994). However, the available data indicate that the cover provides no definitive control on oxidation rates (Bennett 1997).

Summary of Waste Rock Impacts to Water Quality and Water Quantity

West Waste Rock Dump. No impacts to surface water or groundwater quality are anticipated during active mining operations. Model estimates predict that ARD generated from the West Waste Rock Dump will have impacts to groundwater quality, although the time before these impacts are experienced at locations of existing beneficial uses is estimated to be on the order of tens to hundreds of years. Under estimated (modeled) conditions, the Water Management Plan presented in Appendix A will prevent ARD impacts downgradient from the West Waste Rock Dump from migrating outside of the proposed mixing zone boundary (see Appendix B). If the ARD generated by the West Waste Rock Dump is greater than estimated, or if ARD is released from the dump sooner than anticipated along preferential, discrete flowpaths, additional mitigation measures will be required to prevent ARD impacts to surface water and groundwater quality outside of the GSM-proposed mixing zone boundary (see Section IV.P, Potential Mitigation and Monitoring, Measure W-4).

Beneficial uses and potential beneficial uses within the proposed mixing zone boundary are likely to be impacted by ARD from the West Waste Rock Dump, and/or by drawdown effects from the capture well system. The known beneficial use in this area is the Steppan Original Spring which is used as a water source by wildlife. An unnamed spring in St. Paul Gulch is a potential wildlife beneficial use, but no data are available on the ambient water quality or flow in that spring. The Steppan Spring also is located within the West Waste Rock Dump mixing zone, but that spring has such poor ambient water quality that incremental impacts are likely to be negligible. Mitigation of impacts to wildlife use caused by ARD, and by ARD-impacted groundwater capture from the West Waste Rock Dump are described in Mitigation Measures W-1 and W-5, respectively (see Section IV.P, Potential Mitigation and Monitoring).

Water consumption by processes of oxidation and heating within the West Waste Rock Dump will have a negligible impact on groundwater recharge.

East Waste Rock Dump. No impacts to surface water or groundwater quality are anticipated during active mining operations. Model estimates predict that groundwater immediately downgradient from the East Waste Rock Dump will experience an ARD impact of limited extent, returning to a neutral pH within 2,200 to 2,400 feet downgradient from the Dump. No impacts to surface water or groundwater quality are anticipated downgradient from the East Waste Rock Dump outside of GSM's proposed mixing zone (see Figure 5-1 in Appendix B). If the ARD generated by the East Waste Rock Dumps is greater than estimated, or if ARD is released from the dump sooner than anticipated along preferential, discrete flowpaths, additional mitigation measures will be required to prevent ARD impacts to surface water and groundwater quality outside of the proposed mixing zone boundary (see Section IV.P, Potential Mitigation and Monitoring, Measure W-4).

Beneficial uses within the proposed mixing zone boundary are likely to be impacted by ARD from the East Waste Rock Dump. These beneficial uses include the Rattlesnake Spring and the Bunkhouse Spring, which are both wildlife water sources. Mitigation of impacts to wildlife use of these springs is described in Mitigation Measures W-1 (see Section IV.P, Potential Mitigation and Monitoring).

Water consumption by processes of oxidation and heating will have a negligible impact on groundwater recharge.

IV.B.1.b Open Pit

Open Pit Impacts to Water Quality During Mining Operations

Water collected within the mine pit has a significant potential to form ARD. However, during mining operations, water collected in the pit is treated and recycled in the ore processing circuit. Pumping of water from the pit causes a cone of depression in the groundwater table surrounding the pit, such that the net flow is into the pit. Thus, ARD from the pit is not expected to impact the local surface water or groundwater environment during operation. The greater concern during mining operations is the potential for reduced spring flows in and around the mine area as a result of pit dewatering.

Open Pit Impacts to Water Quantity During Mining Operations

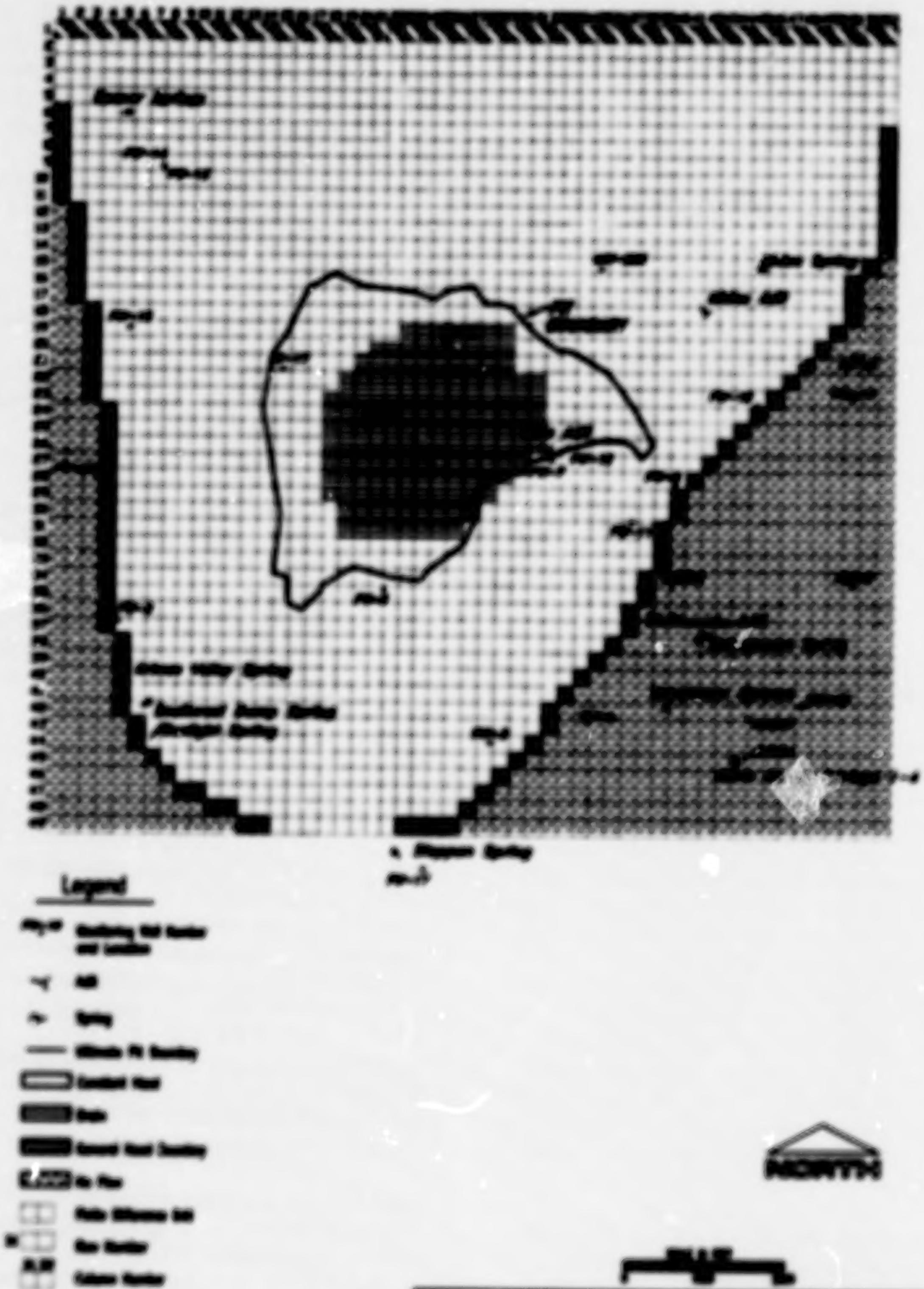
Numerical groundwater model simulations of the local pit groundwater system conducted in 1995 form the primary basis for evaluating impacts to water quantity from pit dewatering (Hydrometrics 1995). The pit is at the center of the modeled area, which extends approximately 1 mile in the north to south direction and 2 miles east to west (Map IV-3). Modeling can only estimate the most probable overall response of groundwater withdrawal on the system. Therefore, results of the model simulations represent the general response of the groundwater system to stresses associated with the pit expansion. A detailed discussion of the groundwater model configuration and input parameters can be found in Appendix 4.7-1 of GSM's Permit Application (GSM 1995b).

Faults and fractures control the permeability of the bedrock unit in the pit area. Due to pit dewatering, the open pit acts as a hydrologic sink that drains internally. Potentiometric contours for the pit area in 1993 are shown on Map IV-4 and indicate a groundwater divide at the ridge west of the pit. Groundwater east of the divide flows toward the pit; groundwater west of the divide flows away from the pit. The minimum groundwater elevation in the pit at the end of the pit excavation under the No Action Alternative will be at elevation 5,075 feet. The minimum groundwater elevation in the pit in 1993 was approximately 5,400 feet. Consequently, it is expected that the pit will be a sink more analogous to that represented in Map IV-9 than the 1993 pit as indicated on Map IV-4.

Groundwater inflows to the pit under the No Action Alternative are estimated to be approximately 30 gpm based upon groundwater model simulations (Table IV-4) (Hydrometrics 1995). During operation, these flows are pumped out of the pit to an existing operational water treatment plant and recycled for use in the ore processing circuit, thus removing this quantity of groundwater from the regional hydrologic system and potentially depressing the local groundwater table. In reality, a cone of groundwater depression will form only if the pit intercepts a significant number water bearing fractures and joints. Consequently, the actual cone of depression may vary from that predicted by the groundwater model simulations.

Discharge at springs and seeps in the vicinity of the pit have the potential to be impacted if the expanding cone of depression from the pit dewatering intercepts interconnected hydrogeologic units and groundwater, which otherwise would discharge to the surface as springs. Because of the small (0.2 gpm to 25 gpm) variable spring flow rates and the complex nature of the hydrostratigraphic units, quantification of incremental changes in spring discharge is neither possible nor practical. Some general observations can be made, however, from existing information.

If groundwater elevations are artificially lowered at spring locations due to dewatering of the pit, some springs could experience reduced flows or cease flowing on a long-term basis. The magnitude of the impact associated with pit dewatering on springs is a function of the mechanism through which the spring receives water and the degree of drawdown. In general, drawdown effects of the pit dewatering on



GOLDEN SUNLIGHT MINE EXPANSION

MAP IV-3

PIT GROUNDWATER MODEL

1993 CONFIGURATION

[illegible]

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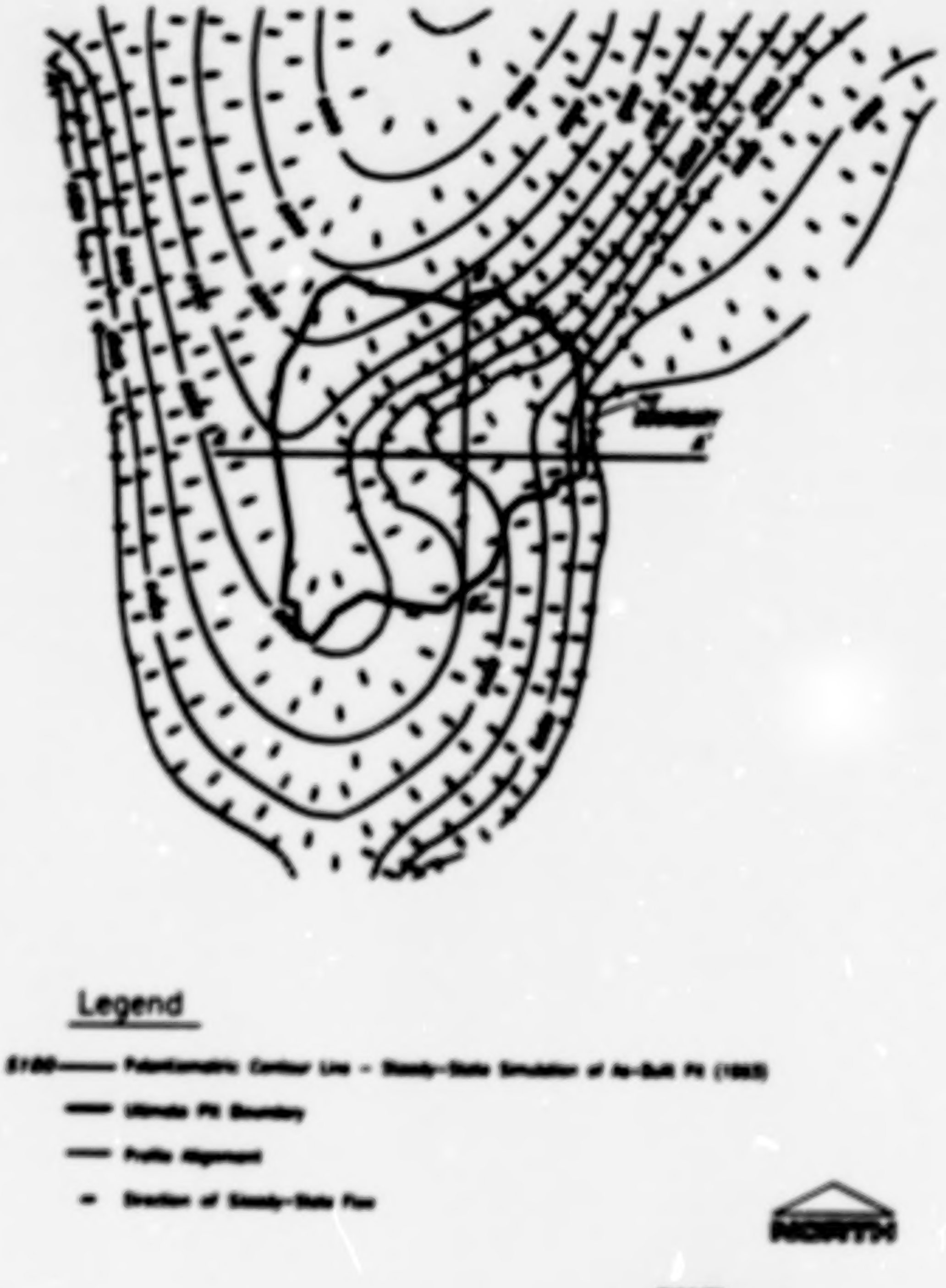
Legend
5100—— Potentiometric Contour Line – Steady-State Simulation of As-Built Pit (1993)
Ultimate Pit Boundary
Profile Alignment
Direction of Steady-State Flow
NORTH

GOLDEN SUNLIGHT MINE EXPANSION

MAP IV-4

STEADY-STATE FLOW SIMULATION

LATE SEASON 1993

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Table IV-4

Estimated Groundwater Inflow to the Pit Under Dewatered Conditions

Simulation Year	Predicted Short-Term Flow Rates (gpm)	Predicted Flow at End of Two-Year Simulation Period (gpm)
1995	--	24.3
1996	30-60	30.0
1998	46-147	45.7
2000	49-118	48.2
2002	53-97	52.5
2004	41-74	51.2
2006	50-62	50.0

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springs will be greater downgradient of the pit than upgradient, and will decrease with increasing distance from the pit.

The Sheep Rock Spring's location 1 mile away, upgradient of the pit will help to minimize impacts to this spring associated with the pit dewatering. Furthermore, any precipitation-driven recharge to the spring from the upper Sheep Rock Creek will not be impacted by the pit dewatering operations. Groundwater generally flows to the southeast, south, and southwest from areas of high topographic relief (GSM 1995b). Consequently, any bedrock flow contribution to Sheep Rock Spring is likely to be coming from northwest of Sheep Rock Spring (upgradient of the pit). While the potential for interception of the fractured flow to the spring cannot be completely eliminated, the above factors suggest impacts to the Sheep Rock spring from pit dewatering under the No Action Alternative are unlikely or minimal.

Rattlesnake Spring is located southeast of the plant site along Rattlesnake Fault. It is roughly 3,700 feet downgradient from the pit at an elevation of approximately 4,900 feet. The spring's source is believed to be the abandoned Rattlesnake Adit. The adit is oriented in an easterly direction (away from the pit) and is believed to intercept the regional groundwater flow via the Bozeman hydrogeologic unit. At the conclusion of mining under the No Action Alternative, the pit bottom and the local pit water table will be at elevation 5,075 feet. Consequently, there will be a positive hydraulic gradient between the pit and Rattlesnake Spring. The positive hydraulic gradient, coupled with the adit being in a different hydrogeologic unit (the Bozeman alluvium) minimize the potential for significant reductions in spring flow.

Bunkhouse Springs are located to the southwest of Rattlesnake Spring, approximately 3,300 feet downgradient from the pit. The springs discharge at an approximate elevation of 4,925 feet. As discussed in Chapter III, Section III.B.2.d, Springs and Seeps, Bunkhouse Springs occur within the debris flow/colluvial materials and appear to be surficial expressions of the regional water table in the area. Similar to the Rattlesnake Spring, being downgradient from the pit and receiving some flow contribution from the bedrock provides a potential mechanism for spring flows to be impacted by the dewatering of the pit. However, a positive hydraulic gradient, coupled with the adit being in a different hydrogeologic unit than the pit bedrock and receiving precipitation and Bozeman alluvium recharge minimizes the potential for significant reductions in spring flow.

Steppan Spring originates from bedrock fractures in an ephemeral stream channel southeast of the existing West Waste Rock Dump Complex. The spring is approximately 3,300 feet downgradient from the pit boundary at approximately 5,000 feet in elevation. Steppan Spring is a discharge point for the bedrock hydrogeologic unit. Under the No Action Alternative, the water level in the pit will remain above the Steppan Spring discharge point, providing a positive gradient towards the spring. The positive gradient will provide the potential for the spring to continue flowing. However, the spring is downgradient of the pit, is contained within the same hydrogeologic unit as the pit, and has little potential for runon recharge or flow from other hydrogeologic units. These factors combine to make the Steppan Spring a likely candidate for reduced discharge associated with the pit dewatering.

The Steppan Original Spring is located approximately 1,600 feet southwest of Steppan Spring at an elevation of approximately 4,900 feet. The spring flows from a collapsed, abandoned adit. Lack of seasonal variation in discharge measurements and the concentrations of sulfate in the discharge samples (see Chapter III, Section III.B.2.d, Springs and Seeps) imply the adit intercepts the regional groundwater flow in the bedrock hydrogeologic unit. Being downgradient of the pit and having the bedrock hydrogeologic unit as the flow source increase the potential for impacts to the spring discharge from the pit dewatering. Because the Steppan Original Spring is farther from the pit, impacts associated with the pit dewatering are expected to be less than for the Steppan Spring.

Beaver Springs are located just north of the northwest corner of the Golden Sunlight Mine area. The springs lie approximately 3,300 feet from the pit boundary on the St. Paul Gulch side of the groundwater divide at an elevation near 5,600 feet. The significant variation in reported flow rates (see Chapter III, Section III.B.2.d) suggests the spring is recharged by runon events and that discharge is affected by variations in groundwater levels. The spring's upgradient location, on the opposite side of the groundwater divide from the pit make reduced flow at this spring an unlikely consequence of the pit dewatering.

The unnamed spring in St. Paul Gulch is downgradient of the pit, but is located on the opposite side of a groundwater flow divide. There is no information available regarding the hydrogeologic source of this spring or its ambient flow and fluctuations. However, its location on the opposite side of the groundwater divide makes it unlikely that this spring will experience reduced flows because of pit dewatering.

In order to help quantify impacts on springs from the pit dewatering, a gross percentage estimate of the potential decrease in spring flow under the No Action Alternative pit elevation has been calculated for the Steppan Spring (which has the greatest potential for reduced discharge associated with the pit dewatering). The change in the hydraulic gradient results in an estimated net unit flow reduction on the order of 28 percent for Steppan Spring. Based upon previous discussion, other springs on the site can be expected to have a lesser degree of impact associated with the pit dewatering. These estimates utilize Darcy's law which requires the use of simplifying assumptions. Due to the fractured nature of the bedrock, actual hydraulic gradients may differ substantially from the calculated hydraulic gradients. Actual variations in spring discharge will vary if local conditions (i.e., hydraulic conductivity) are different from those assumed in the above estimate.

Open Pit Impacts to Long-Term Water Quality

The excavation of the pit under the No Action Alternative is expected to be completed in late 1997 to early 1998. Pit reclamation would then proceed in accordance with the existing reclamation plan, which will reduce runoff and infiltration of surface water through evapotranspiration from vegetation re-established on approximately 19 acres of pit benches. Under the existing reclamation plan, a small (1- to 4-acre) lake will be allowed to form in the bottom of the pit, with water levels controlled between 5,075 and 5,100 feet elevation by pumping an estimated 48 to 54 gpm of water to a permanent water treatment plant for treatment and release.

Water collected from the pit is characterized by low pH, high concentrations of TDS, metals and sulfate. It therefore is ARD in character, and has the potential to impact both surface and groundwater quality. GSM estimates that maintaining a pit lake elevation between 5,075 and 5,100 feet will create a hydrologic gradient for groundwater to flow towards the pit, significantly reducing the potential for contaminated pit water to migrate away from the pit. In addition, the pit excavation to the 5,075-foot elevation remains in the bedrock, thus, there will be no direct groundwater discharge from the pit into the higher permeable colluvium. If fractures exist which provide a hydraulic connection to the colluvium, it will be necessary to maintain the pit groundwater levels below the pit bottom at an elevation 5,050 feet to maintain a hydrologic gradient for groundwater to flow towards the pit. If the No Action Alternative is selected, a monitoring plan downgradient of the colluvium should be implemented in order to detect any hydraulic connection (i.e., fractures) between the pit and the colluvium hydrogeologic unit.

Water quality for the permanent water treatment plant design is based upon the Ohio adit water, pit water and feed water to the existing operational water treatment plant in the processing facility. A detailed discussion of the current permanent treatment plant design is presented in Appendix A, Attachment A-1. After being treated to remove contaminants, water reporting to the permanent water treatment plant will be returned to the regional groundwater system via infiltration. Because all water collected in the pit will be treated in perpetuity, impacts to surface water and groundwater quality from pit reclamation are not expected to occur.

__Open Pit Impacts to Long-Term Water Quantity__

Based upon data in Table IV-5 the estimated maximum rate of water withdrawal by Golden Sunlight Mine to maintain the pit as a sink would range between 48 and 54 gpm. Because pit water elevations will be maintained at, or just slightly above pit water elevations during mining operations (5,075 to 5,100 feet), impacts to springs are expected to remain similar to those that will occur during mining operations (see above). However, if the groundwater system has not reached equilibrium at the conclusion of mining under the No Action Alternative, the radius of influence can be expected to increase until equilibrium is achieved. Consequently, associated long-term impacts to springs may be greater than the estimated operational impacts.

__Summary of Open Pit Impacts to Water Quality and Water Quantity__

Under the No Action Alternative the impacts to water resources from the open pit during mining operations will likely be limited to reduced spring flows as a result of the pit dewatering. Steppan Spring has the greatest potential for reduced flows (on the order of 28 percent) resulting from active pit dewatering. The Steppan Original Spring has less potential for reduced flows than Steppan Spring, but is more likely to have reduced flow than Rattlesnake, Bunkhouse, Sheep Rock, or Beaver Springs. Rattlesnake Spring and Bunkhouse Spring have a greater potential for reduced flow than the Sheep Rock and Beaver Springs, but any reduction in flow is expected to be minimal. Reduced flows are least likely for Sheep Rock and Beaver Springs and the unnamed spring in St. Paul Gulch. If the groundwater system has not reached equilibrium at the conclusion of mining under the No Action Alternative, long-term impacts to springs from pit dewatering may be greater than the estimated operational impacts. To avoid long-term impacts to downgradient springs, a monitoring and spring enhancement plan may be necessary. Mitigation Measure W-1 (see Section IV.P, Potential Mitigation and Monitoring) addresses potential impacts to springs and seeps.

Because the pit will be maintained as a local groundwater sink and pit water will be collected and routed to the permanent water treatment plant before being discharged, no impacts to surface water or groundwater quality are anticipated during mining operations or long-term. If ARD inflows to the pit exceed the expected rates, Mitigation Measure W-6 (see Section IV.P, Potential Mitigation and Monitoring) would provide for additional permanent treatment plant capacity to treat the additional flows.

IV.B.1.c Tailings Impoundments

__Tailings Impacts to Water Quality During Mining Operations__

Operational impacts to water quality are primarily associated with migration of cyanide from the unlined Tailings Impoundment No. 1. Tailings water quality in the impoundment is currently slightly alkaline (pH = 8.1) and contains total cyanide concentrations on the order of 30 to 95 mg/L. Shallow groundwater below Tailing Impoundment No. 1 upwells into tailings material in the area of a historic spring and mobilizes tailing constituents. Presently, this groundwater is mobilizing cyanide and TDS. Under the current operating system, Tailings Impoundment No. 1 impacts to water quality appear to be confined to the mine area. A system of pump back wells intercepts and contains the cyanide plume, as described in Chapter III, Section III.B.2.f, Groundwater in the Tailings Impoundment Areas. Cyanide levels are no longer detectable in several downgradient private wells, indicating that the pumpback system is effective. The process of decommissioning Tailings Impoundment No. 1 began in 1993, and dewatering is expected to be complete in approximately 10 years. Cyanide concentrations in the pumpback water

Table IV-5

Summary of Pit Water Balance for Proposed Action

Post-Mining Year	Water Level Elevation (ft [illegible])	Pit Water Depth (ft)	Pit Water Volume (Mgals)	INFLOW (gpm)					OUTFLOW (gpm)			Total Treated Flow
				Direct Precipitation	Snowmelt	Rainfall Runoff	Ground Water	Total Inflow	Evaporation Outflow	Seepage Outflow	Total Outflow	
1	4700.0	0	0	1.7	7	44.5	49	102.2	4.3	0	4.3	97.9
2	4782.8	82.9	101.27	2.9	6.9	44.2	48.5	102.5	7.3	0	7.3	95.2
3	4807.0	107	150	3.9	6.9	43.9	48.2	102.9	10	0	10	92.9
4	4829.1	129.1	197.58	5	6.8	43.6	47.9	103.4	12.7	0	12.7	90.7
5	4849.5	149.5	244.05	6.1	6.8	43.4	47.8	104	15.5	0	15.5	88.5
6	4868.2	168.2	289.43	7.2	6.7	43.1	47.7	104.7	18.2	0	18.2	86.5
7	4885.3	185.3	333.74	8.3	6.7	42.8	47.6	105.4	20.9	0	20.9	84.5
8	4901.1	201.1	377	9.3	6.7	42.5	47.6	106.1	23.6	0	23.6	82.5
9	4915.6	215.6	419.23	10.4	6.6	42.2	47.5	106.8	26.3	0	26.3	80.5
10	4928.9	228.9	460.45	11.4	6.6	42	47.5	107.5	28.9	0	28.9	78.6
20	5014.2	314.2	824.8	19.9	6.2	39.8	47.3	113.3	50.2	0	50.2	63.1
30	5050.4	350.4	1126.68	24.6	6	38.6	47.2	116.4	62.1	1.7	63.8	52.6
40	5064.5	364.5	1362.89	26.7	5.9	38	47.1	117.8	67.3	9.9	77.2	40.6
50	5070.6	370.6	1558.79	27.6	5.9	37.8	47.1	118.4	69.6	13.5	83.1	35.3
60	5074.5	374.5	1734.08	28.2	5.9	37.6	47	118.7	71.1	15.7	86.8	31.9
70	5078.4	378.4	1892.72	28.8	5.9	37.5	47	119.1	72.6	17.9	90.5	28.6
80	5083.5	383.5	2031.34	29.6	5.8	37.3	47	119.6	74.6	20.7	95.2	24.3
100	5095.7	395.7	2230.05	31.5	5.7	36.8	46.8	120.9	79.5	27.4	106.9	14
110	5100.9	400.9	2289.62	32.4	5.7	36.6	46.8	121.4	81.7	30.4	112	9.3
120	5104.7	404.7	2328.58	33	5.7	36.4	46.8	121.9	83.3	32.5	115.9	6.1

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Table IV-5 (Continued)

Post-Mining Year	Water Level Elevation (ft MSL)	Pit Water Depth (ft)	Pit Water Volume (Mgal)	INFLOW (gpm)					OUTFLOW (gpm)			Total Treated Flow
				Direct Precipitation	Snowmelt	Rainfall Runoff	Ground Water	Total Inflow	Evaporation Outflow	Seepage Outflow	Total Outflow	
130	5107.3	407.3	2352.89	33.5	5.7	36.3	46.7	122.1	84.5	34	118.5	3.6
140	5108.9	408.9	2367.58	33.8	5.7	36.2	46.7	122.3	85.2	34.9	120.1	2.2
150	5109.9	409.9	2376.29	33.9	5.6	36.2	46.7	122.4	85.6	35.5	121.1	1.3
160	5110.5	410.5	2381.39	34	5.6	36.1	46.7	122.5	85.9	35.8	121.7	0.8
170	5110.9	410.9	2384.36	34.1	5.6	36.1	46.7	122.5	86.1	36	122.1	0.4
180	5111.1	411.1	2386.07	34.1	5.6	36.1	46.7	122.6	86.1	36.2	122.3	0.3
190	5111.2	411.2	2387.06	34.2	5.6	36.1	46.7	122.6	86.2	36.2	122.4	0.2
200	5111.2	411.2	2387.63	34.2	5.6	36.1	46.7	122.6	86.2	36.3	122.5	0.1
210	5111.3	411.3	2387.96	34.2	5.6	36.1	46.7	122.6	86.2	36.3	122.5	0.1
220	5111.3	411.3	2388.15	34.2	5.6	36.1	46.7	122.6	86.3	36.3	122.6	0
230	5111.3	411.3	2388.26	34.2	5.6	36.1	46.7	122.6	86.3	36.3	122.6	0
240	5111.3	411.3	2388.33	34.2	5.6	36.1	46.7	122.6	86.3	36.3	122.6	0
250	5111.3	411.3	2388.36	34.2	5.6	36.1	46.7	122.6	86.3	36.3	122.6	0

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are expected to decrease during the 8- to 10-year dewatering period (see Appendix A).

Tailings Impoundment No. 2 has a synthetic liner beneath the tailings to prevent seepage from the tailings into the underlying materials. Water draining from tailings in Tailings Impoundment No. 2 is collected by drains on top of the liner, and is conveyed into the reclaim ponds below the impoundment. Reclaim water is then recycled back into the ore processing circuit in the mill complex. A significant percentage of the recycled water is evaporated from the ponded surface. Localized failure of the Tailings Impoundment No. 2 liner could lead to minor releases of tailings solutions. The likelihood of extensive liner failure during the mine operating life is low, although isolated small leaks in the HDPE are likely. Leakage was detected in the reclaim pond liner in 1995, and measures were taken in 1995 and 1996 to repair the pond liner system as discussed in Chapter III, Section III.B.2.f, Groundwater in Tailings Impoundment Areas. Impacts of the leakage to date have been barely detectable levels of cyanide in the T2PB monitoring/pump back wells immediately downgradient of the reclaim ponds. Small, isolated leaks in the tailings impoundment or reclaim pond HDPE liners would likely have small impacts to groundwater quality in the vicinity of the impoundments. Potential off-site impacts would be mitigated by monitoring and installation of pumpback wells, as described under Mitigation Measure W-8, in Section IV.P, Potential Mitigation and Monitoring.

Two storm water diversion channels capture runoff north of the impoundments and direct flow into ephemeral stream channels on the east and west side of the impoundments (see Map IV-1). These ephemeral stream channels drain directly toward the Jefferson Slough. The east diversion is sized to carry the full Probable Maximum Flood (PMF) based on a 6-hour storm event. The west diversion is under construction, and is designed to carry a one-half PMF storm flow. These diversions provide a high level of protection to the tailings impoundments against run-on and erosion from surface water flows from above the impoundment areas. Thus, the amount of infiltration and erosion on the impoundments will be controlled primarily by the amount of precipitation falling directly on the impoundment surface.

Precipitation falling directly on the impoundments during operation will partially evaporate, and partially infiltrate the tailings material and embankments. Net infiltration will contribute to the total seepage that is pumped back from Tailings Impoundment No. 1, or is collected on the liner and recycled in Tailings Impoundment No. 2. Sloped surfaces, such as on the dam faces will be subject to erosion, but tailings surfaces on the embankments will be covered by a soil cap. A system of berms and swales surround the impoundments, and prevent any eroded sediment from leaving the immediate tailings impoundment area.

No impacts due to ARD formation are expected from the tailings impoundments during operations. While the tailings have a significant concentration of reactive sulfide minerals, existing cyanide operations utilize a high pH, alkaline solution. This solution will be entrained to some degree in tailings that report to the impoundment and will provide a source of buffering for any acidic sulfate solutions (ARD) that are produced by the weathering of the sulfide minerals. Once the INCO/SO_2 cyanide destruction process is implemented (circa 1997) concentrations of cyanide reporting to Tailings Impoundment No. 2 will be significantly reduced. The pH values also may be reduced in the tailings slurry after passing it through the cyanide destruction process, thereby eliminating or reducing any inherent acid buffering capacity in the tailings slurry and creating the potential to form ARD. However, impacts to groundwater during mining operations will be minimized due to the pumpack system downgradient of Tailings Impoundment No. 1 and the liner beneath Tailings Impoundment No. 2.

Tailings Impacts to Water Quantity During Mining Operations

Water is consumed by evaporation from the ponded water on the tailings impoundments. This evaporated water represents a loss to the regional surface water/groundwater system resulting from the operation of the tailings impoundments. Based on the existing surface area of Tailings Impoundment No. 2 (82 acres), an elevation 4,840 feet, and an average evaporation rate of 30 inches per year, up to 127 gpm of water is estimated to evaporate.

Tailings Impacts to Long-Term Water Quality

Under the current reclamation plan, the tailings impoundments will be reclaimed by dewatering, consolidation, grading, capping, and vegetating the surfaces. Capping under the No Action Alternative will consist of a 24-inch soil material cover on top of 18 inches of a clay layer on top of 24 inches of local borrow. Research on Tailings Impoundment No. 1 (Dollhopf 1995) indicates the capping system in the existing reclamation plan minimizes water infiltration, but does not exclude oxygen. Therefore, in time, the tailings will acidify providing a potential for ARD. Potential impacts to water quality are dependent upon the amount of water infiltrating the reclaimed caps, which will be the source for ARD formation and groundwater loading.

The clay layer proposed as part of the tailings covers may be subject to cracking because of desiccation or freeze/thaw. Mitigation Measure W-7 (see Section IV.P, Potential Mitigation and Monitoring) addresses this issue.

Run-on to the tailings impoundments will continue to be controlled by the diversion system described previously. The impoundments will continue to be protected from surface water runoff from outside of the impoundment areas. The tailings will be dewatered by pumping and/or decanting to a sprinkler system along tailings beaches to aid evaporation. The tailings will dewater over time by drainage and evaporation.

As discussed previously, Tailings Impoundment No. 1 is currently being dewatered. The groundwater mound and cyanide plume associated with Tailings Impoundment No. 1 will decay over time. Studies conducted in relation to the permanent water treatment plant indicate that during the a 10-year period of drainage and consolidation, the cyanide concentration in groundwater that is intercepted and pumped back from below Tailings Impoundment No. 1 will continue to decrease. After about 10 years cyanide levels will decrease due to natural degradation and dilution from groundwater. Tailings seepage will become acidic as neutralizing capacity is used up. Presently, groundwater beneath Tailings Impoundment No. 1 is mobilizing cyanide and TDS. In the future, this water could mobilize ARD constituents as the tailings become dewatered and exposed to oxygen. Mitigation Measure W-9 (see Section IV.P, Potential Mitigation and Monitoring) addresses this issue. Long-term ARD concentrations from tailings seepage are assumed to be at least ten times lower than the pit water because of mixing and dilution (see Appendix A) with underlying groundwater.

The HDPE liner and drain system in Tailings Impoundment No. 2 would limit seepage into the underlying native soils. The collected seepage will be continuously recycled and spray evaporated. GSM plans to incorporate an INCO SO_2/AIR cyanide destruction circuit in 1997, which will reduce cyanide concentrations in Tailings Impoundment No. 2 and reduce cyanide treatment requirements.

Localized failure (leaks) in the liner under Tailings Impoundment No. 2 are more likely to occur over the long-term. Groundwater impacts would be negligible under Tailings Impoundment No. 2 as long as the liner system remains intact. Leaks in the primary liner under the double-lined east reclaim basin would be detected and contained by the leak detection system if appropriate monitoring is maintained. Leaks in the impoundment liner would be detected and controlled by appropriate monitoring/pumpback well systems, as described under Section IV.P, Potential Mitigation and Monitoring, Measure W-8. Uncontrolled leakage from Tailings Impoundment No. 2 would likely result in impacts to downgradient domestic and agricultural beneficial uses which are shown on Map IV-2.

The total amount of water in Tailings Impoundment No. 2 would be gradually reduced through the recycling and evaporation process until the rate of consolidation and drainage is greatly reduced. Considering the overall reduction in the rate of seepage with time, it is anticipated that unavoidable groundwater impacts in the immediate vicinity of the impoundment also will diminish with time.

Once the tailings materials are dewatered and the vegetative cover becomes effective in minimizing infiltration, seepage will greatly diminish through the tailings material. Field studies conducted by GSM (GSM 1995b, Appendix 5.5-2) indicate capping and vegetating of the tailings impoundments will reduce infiltration into the tailings materials by encouraging evapotranspiration. Results reported by Dollhopf and others (GSM 1995b) indicate that long-term infiltration of direct precipitation through the tailings impoundment cover will be small to negligible. Once the total seepage rate is sufficiently small (less than about 10 gpm) it will be pumped to the permanent water treatment plant described in Appendix A, treated, and discharged away from the impoundments.

Tailings Impacts to Long-Term Water Quantity

Water will be lost in the evaporation circuit on Tailings Impoundment No. 2 until the facility is sufficiently dewatered to route the residual seepage to the permanent water treatment plant. There will be no long-term water quantity impacts attributed to the tailings impoundments.

Summary of Tailings Impacts to Water Quality and Water Quantity

Under the No Action Alternative impacts to water resources from the tailings impoundments are associated with reduced groundwater recharge attributed to impoundment evaporation during mining operations. Evaporative losses are estimated to be on the order of 130 gpm. Because seepage from Tailings Impoundment No. 1 will be collected and treated, potential impacts to water quality are limited to the local cyanide plume associated with Tailings Impoundment No. 1.

Over the long-term, potential leakage from the Tailings Impoundment No. 2 HDPE liner is likely to occur. Uncontained, this leakage would likely impact downgradient beneficial uses. Leakage, and impacts, would diminish with time as the tailings are dewatered through evaporation. Potential monitoring and mitigation measures for liner leakage are described in Section IV.P, Potential Mitigation and Monitoring, Measure W-6.

IV.B.1.d Mill Area and Support Facilities

Mill Area and Support Facilities Impacts to Water Quality During Mine Operations

Mill area facilities during mine operation include the ore processing plant, administration and maintenance buildings, an employee parking lot, and a septic system. Solid waste landfills are located within waste rock dumps. Each of these facilities creates a potential for increased erosion and sedimentation that could impact surface water quality. Handling of runoff from waste rock dump areas, some of which include the solid waste landfills, was discussed in Section IV.B.1.a, Waste Rock Dumps. Runoff from the mill area and support facilities area will gather sediment from the exposed soils on parking lots, roads, and other work areas. Surface water runoff from the mine facilities areas are routed onto natural slopes surrounding the facilities area, and discharged through riprap diffusion structures. Transport of sediment from these areas is expected only in response to intense storm events.

Spills of ore processing solutions or fluids from vehicles in the mill area and support facilities represent minimal risk to groundwater quality. As long as the mine's spill contingency plan is followed, no impacts are anticipated.

Mill Area and Support Facilities Impacts to Long-Term Water Quality

Reclamation of the plant site will include removal of all structures, testing for potential acidity, and reclamation of acid-producing areas by use of a reclamation cap. The site will be graded, covered with soil, and revegetated. Revegetation of the mill area and support facilities areas will provide erosion protection, and will minimize infiltration by encouraging evapotranspiration. Surface runoff volumes and erosion of sediment from these areas will be reduced by revegetation, minimizing or eliminating impacts to surface water quantity and quality.

IV.B.1.e Permanent Water Treatment Plant

Estimated Inflows to Permanent Water Treatment Plant

Under the reclamation plan a permanent water treatment plant will be constructed to treat contaminated water from the pit, tailings impoundments, and miscellaneous small-quantity sources (GSM 1996a). The treatment plant design originally submitted under the permit application (GSM 1996a, Appendix 13) was revised in August 1996, to accommodate greater inflows from the Tailings Impoundment No. 1 groundwater pumpback system, and to treat poorer water quality than the original treatment plant. The design was again revised in July 1997, to accommodate, in addition, potential inflows from a West Waste Rock Dump groundwater capture well system, plus contingencies, as described in the Long-Term Water Management Plan (see Appendix A). The new treatment facility will combine the treatment of tailings, waste dumps, and pit water in a single process and is currently designed to accommodate inflows of up to 316 gpm.

Pit dewatering rates under the No Action Alternative are estimated to be between 35 gpm (short-term) and 54 gpm (long-term). Tailings Impoundment No. 1 pumpback wells will continue to intercept groundwater below the impoundment. Since decommissioning of Tailings Impoundment No. 1 began in 1993, the rate of seepage captured from the east flank and south pumpback wells has declined from 572 gpm to 266 gpm in 1996 (see Appendix A). The pumpback discharges are expected to continue to diminish for about 8 to 10 years as the tailings consolidation process slows and drainage from the impoundment contributes less to the groundwater system. The long-term pumpback rate is estimated to be approximately 200 gpm, most of which will be from groundwater underflow. These flows may be further reduced or eliminated if Mitigation Measure W-8 is implemented to intercept groundwater upgradient of Tailings Impoundment No. 1, and proves to be effective in isolating the tailings from groundwater in Rattlesnake Gulch. Tailings Impoundment No. 2 will contribute an estimated 10 gpm or less after reclamation is completed.

The proposed Long-Term Water Management Plan (see Appendix A) includes monitoring and implementation of mitigation measures to capture and treat groundwater impacted by long-term ARD from the West Waste Rock Dump. Maximum expected inflow rates from a West Waste Rock Dump groundwater capture well system are 52 gpm (see Appendix L).

Based on these estimated inflow rates, the permanent water treatment plant will need to treat an estimated maximum of 301 gpm at the end of mining under the No Action Alternative. This short-term estimate assumes current maximum discharges from the pit and current Tailings Impoundment No. 1 pumpback (35 and 266 gpm, respectively), and no contribution yet from Tailings Impoundment No. 2.

Over the long-term, the maximum anticipated pumpback from Tailings Impoundment No. 1 is expected to decrease to 200 gpm, and the inflow from Tailings Impoundment No. 2 seepage is estimated to be 10 gpm. These inflows plus the ultimate maximum pit water inflows of 54 gpm result in a combined long-term inflow of 264 gpm under the No Action Alternative. The currently designed plant capacity of 316 gpm is sufficient to accommodate, in addition, a reasonably expected inflow rate (52 gpm) from an efficient West Waste Rock Dump groundwater capture system.

The currently proposed treatment plant under the Proposed Action (see Appendix A) is designed with contingencies to handle flows up to 382 gpm. Thus, the Proposed Action water treatment plant that is described in Appendix A, if implemented, would be adequately sized with about a 20 percent bonding contingency to handle the maximum anticipated inflows for the

No Action Alternative. GSM has committed to preparing a final design for the permanent water treatment plant at mine closure to account for all potential inflows.

Permanent Water Treatment Plant Impacts to Long-Term Water Quality

The water treatment process generates sludge, to be dewatered in a filter press and then land-filled within the permit boundary. The sludge disposal plan was revised in November 1995, to accommodate greater inflows and poorer water quality than the original sludge disposal plan (see Appendix C). Sludge produced from the water treatment plant is to be land-filled within Tailings Impoundment No. 2. Sludge will be placed in the sludge landfill at a rate of about 8.6 cubic yards (compacted) per day for the first 10 years of plant operation, and 10.7 cubic yards (compacted) per day thereafter. Tailings Impoundment No. 2 will provide adequate storage area for over 1,000 years of sludge production at these projected rates. Should sludge storage be required beyond this capacity, additional storage in Tailings Impoundment No. 2 would need to be provided for, or an alternative disposal site would need to be identified.

Protection of the groundwater system from any potential leachate from the sludge will be provided by the HDPE liner to be placed over the surface of Tailings Impoundment No. 2 prior to sludge disposal. The existing liner below Tailings Impoundment No. 2 will provide secondary protection against leakage of leachate from the sludge. Once sludge placement is completed in a given sludge cell, the surface of the cell will be covered with a geomembrane liner and reclaimed to prevent infiltration of surface water into the sludge. Due to the lining to be provided in each cell, impacts to groundwater quality from sludge production is not anticipated. As described in Appendix C, surface water from active sludge cells will be collected and routed through the water treatment plant. Consequently, the only potential impacts to surface or groundwater quality from sludge production would occur as a result of failure of the treatment plant. Treatment plant failure resulting in environmental degradation is considered unlikely because the system is automatically monitored, and will have an on-site operator. This is discussed in the Water Treatment Plant Failure Modes and Effects Analyses presented in Appendix K.

Permanent Water Treatment Plant Impacts to Long-Term Water Quantity

The sludge storage cells will be lined both above and below the sludge, and the sludge will be placed with a final moisture content of 30 percent. Therefore, some water will be permanently stored within the sludge. Impacts to water quantity will occur as approximately 0.86 acre-feet per year will be lost from the groundwater and surface water systems due to this permanent storage.

Treated water will be discharged to a nearby percolation pond where it will re-enter the local groundwater system at a rate of approximately 250 gpm. Approximately 2.8 acre-feet per year will evaporate from the pond and be lost from the local groundwater system. The proposed water treatment system is intended to continue water treatment in perpetuity. Consequently, the discharges from the plant also will continue indefinitely. Long-term effectiveness of the percolation pond could be reduced by the introduction of sediment into the pond over long-term operation. However, this is not anticipated since the automatic plant controls will detect the release of sediment into the percolation ponds, and allow correction.

Other Long-Term Impacts Associated with Perpetual Water Treatment

Other long-term effects of the permanent water treatment plant include periodic replacement of plant components. Over the expected life (in perpetuity) of the water treatment processing, virtually all components of the plant would be expected to require replacement periodically. Bond requirements should include consideration of periodic reconstruction or replacement of treatment plant components. This replacement would not add any additional environmental effects to the site beyond those associated with active construction. Exhausted plant components which are removed would be disposed of in the same manner as conventional industrial equipment, and would impose no environmental impacts, other than taking up space in a landfill, or costs for recycling or refurbishing. Long-term environmental impacts of perpetual water treatment would include perpetual power consumption. Other perpetual impacts would be associated with required access and maintenance associated with haul roads, transport of materials, and consumption of treatment chemicals.

Treatment Plant Reliability

No studies have been identified that address the performance reliability of water treatment plants of the type proposed for this project. In most cases, a water treatment plant is designed to fulfill a specific purpose relative to the removal of contaminates and consequently is a unique facility. Since most water treatment plants and treatment requirements are unique, predicting reliability using historical performance of similar plants is generally not possible.

Water treatment plant performance reliability is normally high in cases where the plant is properly designed, operated, and maintained. Poor performance reliability associated with plant design is typically attributable to selection of improper treatment processes for the water to be treated, or related to the selection of the equipment associated with the process. Variability in water quality and quantity also can cause erratic plant performance, especially if the process and/or equipment has been designed without adequate consideration for such variability or without adequate factors of safety.

Appropriate attention must be given to the day-to-day operation of a water treatment plant if reliable and consistent performance is to be achieved. The more complex the treatment processes and the more sophisticated the equipment required in the process, the higher the degree of risk of short- or long-term failure. Such risks are easily managed if adequate funds are available to hire a sufficient number of properly trained people to operate the facility. Operational plant performance upsets typically can be reduced to a small number in cases where an adequate number of properly trained operators are available to run the plant.

Regular maintenance of the plant equipment is another important consideration to ensure consistent performance. Typically, regular maintenance procedures must be followed on a routine basis to minimize equipment failure and maximize equipment life. Equipment must be replaced at or before reaching its design life to ensure high levels of operating reliability and reduce complete plant shutdowns due to equipment failures.

In summary, a high degree of overall performance reliability can be expected if the treatment plant is correctly designed, staffed and operated in accordance with a properly prepared operations manual, maintained in accordance with the equipment manufacturers recommendations, and equipment is replaced at appropriate intervals.

A report included as Attachment A-1 to Appendix A describes, in general terms, a conceptual design of the proposed water treatment facility. A single treatment facility is proposed to treat the pit water and tailings water. The process proposed consists of lime addition to raise pH to between 9 and 10.5, cyanide destruction using hydrogen peroxide, hydroxide precipitation, flocculation, settling, and acidification back to pH 6 to 9. Sludge would be dewatered and disposed of in an on-site sludge landfill.

The proposed conceptual design should provide satisfactory results assuming all elements of the report are followed. The report in Appendix A states that " Use of a single process to treat both pit and tailings water is technically feasible, but would need to be investigated further in bench-scale tests to determine if it is practical and cost-effective for meeting effluent quality requirements." Assuming that bench scale tests are performed as part of the final design process, and that the information derived from these tests is correctly incorporated into the final design, the ultimate treatment objectives can be achieved.

IV.B.2 Proposed Action Alternative

IV.B.2.a Waste Rock Dumps

Concerns for water resources associated with the waste rock dump ARD are the same as were described for the No Action Alternative. The Proposed Action would result in a 42 percent increase in area of waste rock dumps (areas to be covered with sulfide waste rock), from 802 acres to 1,137 acres. Thus, increased ARD production is expected in comparison with the No Action Alternative.

Under the Proposed Action, the upper portion of Sheep Rock Creek would be diverted via a vegetated and riprapped channel into a tributary of Conrow Creek. Conrow Creek is tributary to the Boulder River, which currently receives no runoff from the Golden Sunlight Mine. One component of the upper Sheep Rock Creek runoff is from the East Waste Rock Dump.

Waste Rock Impacts to Water Quality During Mining Operations

Construction and operation of the Proposed Action would result in expansion of the existing East Waste Rock Dump. Active waste rock dump areas would be subject to the same conditions and control measures as were described for the No Action Alternative. Realignment of existing surface water collection channels and construction of new channels would occur under the Proposed Action to control storm water, as needed, and to prevent runoff from exposed dump areas from entering creek drainages flowing out of the mine site.

Waste rock dumps would be reclaimed as dump areas are completed during operation. It is anticipated that the total area of unreclaimed dump surfaces would not vary significantly from that during operation of the No Action Alternative. Consequently, no unique impacts to groundwater or surface water associated with the waste rock dumps are expected during mining operations under the Proposed Action, as compared to the No Action Alternative.

The proposed area of new disturbance is located to the south and southeast of Bull Mountain on a predominately southeast dipping slope between Bull Mountain and the Jefferson Slough (see Chapter III, Map III-4). There are no perennial streams within the proposed new disturbance area, however, the area is drained by several well-defined ephemeral stream channels. The East Waste Rock Dump expansion would cover portions of the existing Sheep Rock Creek channel. No further expansion of the West Waste Rock Dump is planned, so no additional production of ARD from that facility would occur. Thus, all additional waste rock dump construction/expansion would occur on the eastern portion of the Golden Sunlight Mine site.

Sheep Rock Creek would be filled with clay-capped inert material to the diversion channel elevation above the East Waste Rock Dump. Assuming the final design for this channel meets the stated design criteria and is built according to the plans and specifications, this structure would protect the waste rock dump materials from direct contact with Sheep Rock Creek flows up to and including the one-half PMF event (976 cfs). Failure of the diversion channel structure could result in storm water contacting a dump surface and provide a mechanism for ARD. Scheduled operational inspections and maintenance would minimize the potential for structural failure of the diversion. Mitigation Measure W-11 in Section IV.P, Potential Mitigation and Monitoring, addresses damage to the permanent diversion of Sheep Rock Creek at flood flows less than the one-half PMF. A cross-section of the diversion structure is shown in Chapter II, Figure II-2.

Due to the increase in discharge, there exists a potential for sediment erosion impacts to the Conrow Creek drainage. These impacts could consist of streambank erosion and/or sediment deposition. The Conrow Creek tributary channel which would directly receive the upper Sheep Rock Creek runoff has the most potential to be impacted. GSM has committed to visually inspecting Conrow Creek and its tributary channel after storm events and stabilizing the channel, if needed. Potential mitigation measures to address these impacts are described in Section IV.P, Potential Mitigation and Monitoring, Measure W-3. Under current conditions, a retention basin at the outfall of Conrow Creek prevents direct discharge to the Boulder River.

Waste Rock Impacts to Long-Term Water Quality

Reclamation methods for the waste rock dumps under the Proposed Action are the same as those described previously under the No Action Alternative. Additional long-term impacts to water quantity from the Proposed Action's Waste Rock Dump reclamation plan are associated with the Sheep Rock Creek diversion into Conrow Creek, and are the same as those discussed under the operational impacts.

Estimation of Long-Term ARD Production by Waste Rock Dumps. Increased ARD production over the No Action Alternative is expected. The increase is due to expansion of the East Waste Rock Dump. ARD is expected to increase in direct proportion to the increase in surface area of the dump, and is due simply to the increase of surface area available for direct precipitation infiltration. As shown in Appendix J, however, the incremental impact from the Proposed Action relative to the No Action Alternative, would be relatively insignificant. The ARD-related impacts to groundwater quality in the immediate vicinity of the dumps, as evaluated by estimated metals concentration ranges shown on Table IV-3, are the same for this alternative as for the No Action Alternative. The relatively small incremental increases in dump footprint areas and infiltration quantities do not have detectable effects on the extent and timing of ARD-associated metals concentrations within the inherent range of error of the ARD fate and transport simulation (see Appendix J).

Because of the relatively small contribution and ephemeral nature of Conrow Creek, no significant impacts to water quality in the Boulder River are anticipated. Under extreme storm events, waste rock runoff could commingle with flows in the Boulder River via Conrow Creek. However, impacts to the Boulder River under these conditions are unlikely because of dilution. Also, as stated in Chapter III, discharge to the Boulder River from Conrow Creek has never been observed. Consequently, impacts to the Boulder River are considered unlikely.

Waste Rock ARD Impacts to Beneficial Uses Under the Proposed Action. Known beneficial uses of water in the mine area are shown on Map IV-2, and are described under the No Action Alternative. Potential impacts to beneficial uses of water under the Proposed Action are the same as for the No Action Alternative.

Long-Term Monitoring and Treatment for Waste Rock ARD. GSM has submitted a Proposed Long-Term Water Management Plan that describes proposed long-term monitoring and treatment of ARD (Appendix A). GSM proposes a monitoring program where monitoring wells downgradient of the Waste Rock areas have a spacing of 1,000 to 2,000 feet. The layout of monitoring wells (existing and proposed) shown on Figures A-1 and A-2 in Attachment A-2 of Appendix A is generally adequate in terms of numbers of wells for the Proposed Action. However, a detailed exploration program is needed to determine the location and orientation of significant fracture zones in the West Waste Rock Dump area. Well spacings of 1,000 to 2,000 feet may be inadequate if those wells are not located in a fracture zone. Each fracture zone should have a monitoring well penetrating its saturated portion. Comparison of the approximate layout of monitoring wells along the west side of the West Waste Rock Dump with geologic mapping suggests that some fracture zones were probably missed and a reassessment may be needed. The data analysis format appears to be adequate.

GSM has committed to installing a groundwater control system if and when it is needed to mitigate ARD impacts (see Appendix A). GSM initiated a study to evaluate the feasibility and potential effectiveness of groundwater capture systems for the East and West Waste Rock Dumps (Hydrometrics 1996). The Hydrometrics study concluded that groundwater capture is feasible at high capture efficiencies (greater than 95 percent), but that the number and spacing of capture wells could be determined only after site-specific testing is done in the impacted areas.

The EIS review team performed an independent evaluation, using a conceptual capture system design, and site-specific hydrogeologic parameters. This evaluation is provided in Appendix L. Results of the capture system evaluation indicate theoretically high capture efficiencies (approximately 98 to 100 percent) can be achieved using closely spaced interception wells in the Bozeman aquifer system. However, high capture efficiencies are possible downgradient from the West Waste Rock Dump only if the interception wells intersect preferential flow paths which exist in the Bull Mountain bedrock. Capture efficiencies are greatly reduced if the system misses preferential paths of flow downgradient of a contaminant plume. This concern is especially important downgradient from the West Waste Rock Dump because groundwater flow in that area is likely to be concentrated within fractured zones of the bedrock, which have substantially higher hydraulic conductivities than the surrounding intact rock. The modeling exercise showed that capture efficiency is reduced to 80 percent if a single fracture zone is missed. This estimate is based on reasonable assumptions for the relative fractured versus unfractured bedrock hydraulic conductivities, and estimates of the percentage of the total flow area that is fractured. Although in theory, wells would have to be placed only in the fracture zones (which might be broadly spaced), close well spacings were assumed for the conceptual analysis on the west side to ensure high capture efficiency for the pumpage rate estimates.

Pumpage rates to produce high capture efficiencies were estimated for the conceptual capture system that is described in Appendix L. These pumpage rate estimates are shown on Table IV-6.

The currently proposed water treatment facility has sufficient capacity to treat inflows from the proposed West Waste Rock Dump capture system. A capture system is not anticipated to be needed for the East Waste Rock Dump, but is included in the evaluation as a contingency (see Appendix A). It is not considered necessary to enlarge the capacity of the current design to accommodate these inflows.

Pump-and-treat technology is known to be effective for control or containment of groundwater, but is generally considered ineffective for aquifer restoration because of the excessively long time periods required to reduce concentrations to health-risk based levels. The reasons for this are summarized in the literature review provided in Appendix L. The substantial mitigation of potential ARD impact that is provided by surface runon and infiltration controls under the current plan will protect the groundwater resource for many years. But when and if the ARD impact is realized in the groundwater aquifers, and a capture/treatment system has been installed, it may be reasonable to seek other possible mitigation measures (see Section IV.P, Potential Mitigation and Monitoring, Measure W-4).

Table IV-6

Estimated Pumpage Rates for Conceptual Groundwater Capture System
Proposed Action Alternative

Waste Rock Dump	Pumpage Rate (gpm)	Capture Efficiency Range
West	50	80 to 100%
East (Contingency Only)	125	98-100%

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Waste Rock Impacts to Water Quantity

The Sheep Rock Creek diversion (see Map IV-5) would increase the drainage area of the Conrow Creek basin by approximately 1.2 square miles. This increase in drainage area would generate an additional 15 cfs in Conrow Creek during the 100-year, 1-hour precipitation event (GSM 1996d). The main branch of Conrow Creek drains an area of approximately 5.8 square miles and discharges approximately 50 cfs during the same design event, not including the proposed Sheep Rock Creek diversion contribution. Thus, the estimated flows in Conrow Creek under the Proposed Action due to the 100-year design storm would be approximately 65 cfs. Due to the increase in discharge there exists a potential for changes in channel geometry of Conrow Creek. Upper Sheep Rock Creek basin will no longer contribute surface water runoff to lower Sheep Rock Creek basin. Consequently, water quantity in lower Sheep Rock Creek basin will be reduced by the amount diverted into the Conrow Creek basin.

Summary of Waste Rock Impacts to Water Quality and Quantity

In summary, operational water resources impacts that are attributed to the waste rock dumps under the Proposed Action are primarily associated with potential additional sedimentation and erosion that will result from the diversion of storm water into Conrow Creek. In the long-term, ARD from the waste rock dumps constructed under the Proposed Alternative would have similar impacts to groundwater quality within the proposed mixing zone as was described for the No Action Alternative (see Table IV-3). Groundwater resources downgradient of the East Waste Rock Dump will be protected by the attenuation and dilution effects of the Bozeman aquifer, and the proposed groundwater capture system for the West Waste Rock Dump would provide effective, long-term protection of downgradient resources if properly designed, installed, and monitored.

Long-term impacts to water resources that are associated with the waste rock dumps for the Proposed Action are:

- Additional sedimentation and erosion resulting from the diversion of storm water into Conrow Creek (see Mitigation Measure W-3, Section IV.P, Potential Mitigation and Monitoring) addresses impacts from erosion due to increased flows in Conrow Creek);

- A local reduction in water quantity in lower Sheep Rock Creek basin equal to the amount of storm water diverted into Conrow Creek basin; and

- Increased ARD would be generated over that produced by the smaller waste rock dumps of the No Action Alternative. However, the impacts to groundwater and surface water from ARD would likely be negligible because of the proposed groundwater monitoring and capture system. Potential impacts are summarized as follows:

  - No impacts to surface water or groundwater quality are anticipated during active mining operations.

  - ARD from the waste rock dumps would likely have impacts to groundwater quality in the immediate vicinity of the dumps and within the proposed mixing zone limits, although the time before these impacts would be experienced is estimated to be decades to hundreds of years. It is technically feasible to effectively mitigate the ARD impacts downgradient of the mixing zones that have been proposed by GSM (see Appendix B).

  - Effective mitigation of groundwater impacts downgradient of the West Waste Rock Dump will require a highly efficient groundwater capture system, which is part of the Water Management Plan that has been proposed by GSM (see Appendix A). High capture efficiencies (up to 100 percent) can be achieved if all

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fracture zones in ARD-plume paths are penetrated by at least one interception well.

- ARD impacts are expected to be confined to within 2,200 to 4,400 feet downgradient of the East Waste Rock Dump because of attenuation and dilution in the Bozeman aquifer. This distance lies within the proposed mixing zone boundaries. ARD could migrate from the East Waste Rock Dump along discrete, preferential flow paths that are not attenuated as predicted by the fate and transport models. These isolated plumes would be intercepted by additional capture wells, as described by Mitigation Measure W-4(a).

- ARD could migrate from the waste rock dumps in shallow "perched" water tables that are not intercepted by the West Waste Rock Dump capture wells, or are not attenuated in Bozeman aquifer materials downgradient of the East Waste Rock Dump. Mitigation Measures W-4(b) and (c) (in Section IV.P, Potential Mitigation and Monitoring) describe additional capture options to address shallow-depth groundwater flows that are impacted by ARD.

- Water consumption by processes of oxidation and heating will have a negligible impact on groundwater recharge.

IV.B.2.b Open Pit

Concerns for water resource impacts associated with the open pit are the same as those for the No Action Alternative.

Open Pit Impacts to Water Quality During Mining Operations

The operational impacts related to ARD in the open pit are similar to the impacts associated with the No Action Alternative except that flows will be greater, as discussed below. Water accumulating in the pit sump would require treatment prior to discharge.

Open Pit Impacts to Water Quantity During Mining Operations

Under the Proposed Action, expansion of the main pit would increase the total surface area draining into the pit by approximately 24 acres. The pit area would expand from 312 to approximately 336 acres and the main pit bottom would be deepened to 4,700 feet in elevation. All precipitation falling within the limits of the pit would be collected in the pit and treated with groundwater collected in the pit sumps and recycled in the process circuit. Modification of run-on diversion structures associated with the Proposed Action pit design would prevent runoff from areas outside of the pit from entering the pit.

The additional excavation and dewatering of the pit would affect both groundwater elevations and groundwater flow directions. The primary impacts associated with additional groundwater withdrawal would be an increase in the drawdown cone of depression and alteration of the groundwater flowpaths during the period of mining. Potential operational impacts to groundwater quantity associated with the excavation and dewatering of the pit include:

- Reduced flows at some springs;

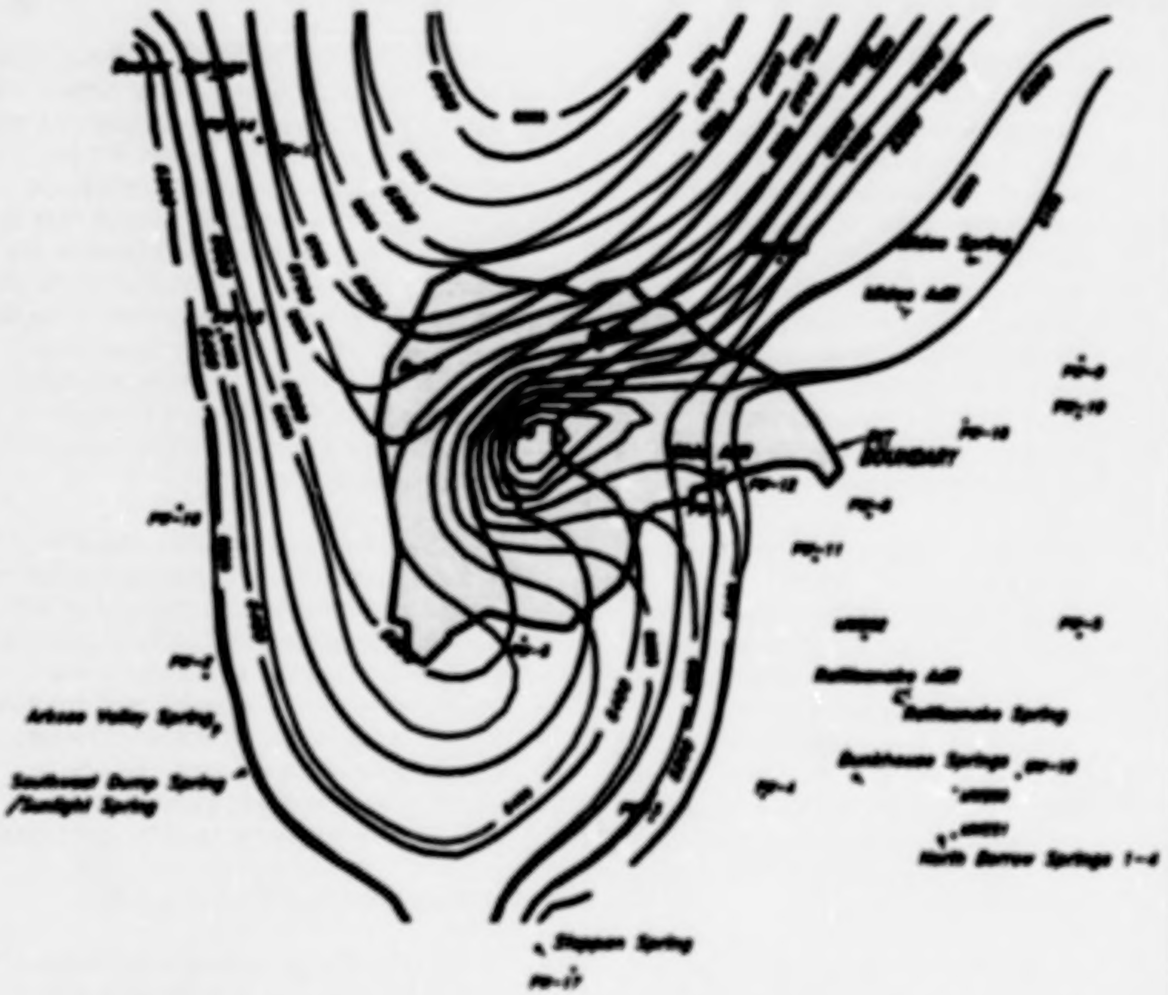
- A net loss of groundwater discharge to the local system, and a slight reduction of groundwater availability to the regional system;

- Altered groundwater flow between local drainages;

- Lower groundwater levels adjacent to the pit; and

- A net loss of surface water recharge to the local system.

As discussed previously in Section IV.B.1.b, Open Pit, under the No Action Alternative, numerical groundwater simulations (Hydrometrics 1995) form the basis for impact analysis. Map IV-6 shows the calibrated 1993 groundwater elevations and the predicted groundwater elevations at the conclusion of the



Legend

5100 ▬▬ Potentiometric Contour Line – Steady-State Simulation of As-Built Pit (1993)

5100 —— Potentiometric Contour Line – Ultimate Pit Simulation Under Dewatered Conditions (2006)

PQ-10 Monitoring Well Number and Location

Adit

Spring

Ultimate Pit Boundary

NOTE: All elevations are relative to GSM datum. Subtract 91.5 feet to convert elevations to USGS mean sea level datum.

GOLDEN SUNLIGHT MINE EXPANSION

MAP IV-6

ULTIMATE PIT SIMULATION VERSUS 1993 STEADY-STATE SIMULATION

SOURCE: HYDROMETRICS 1995 SHEET 1, SHEET 2

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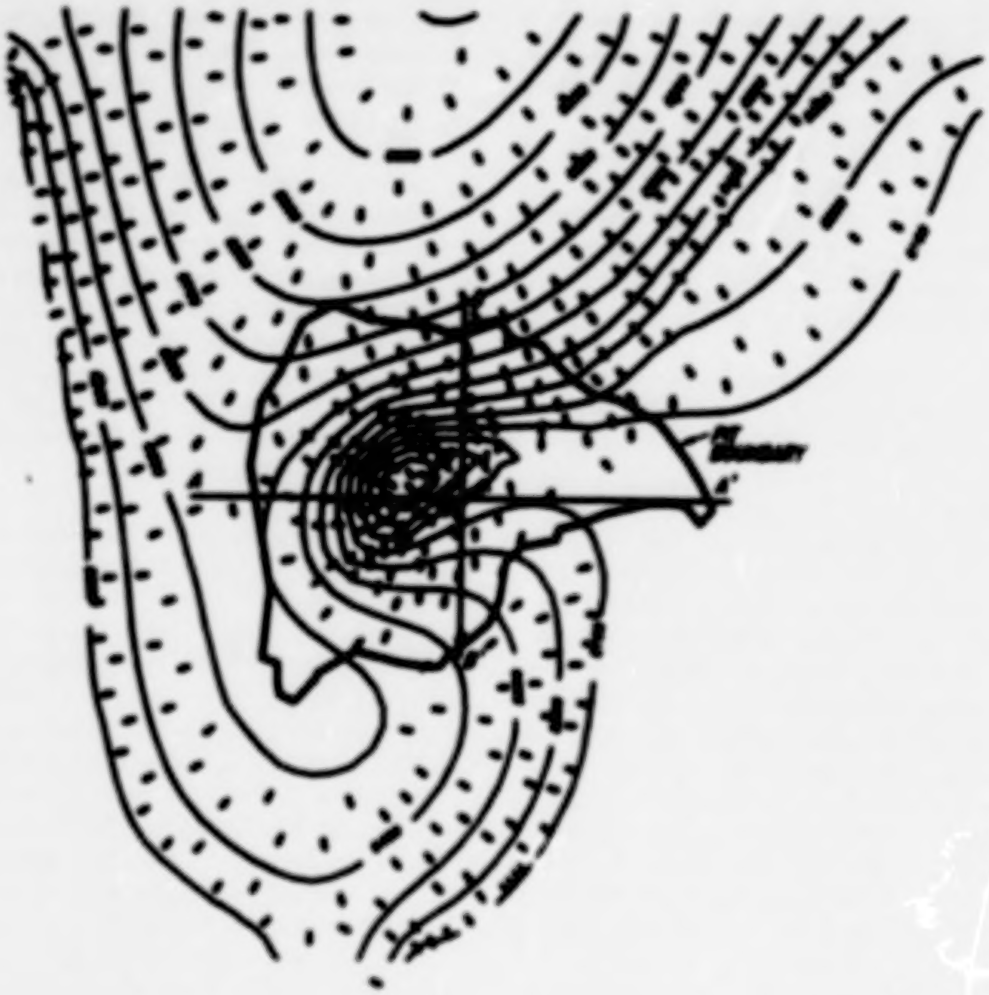
Proposed Action pit expansion (year 2006). Groundwater levels at the end of the No Action Alternative are expected to be locally lower than the 1993 groundwater levels due to the additional permitted pit excavation. Consequently the incremental difference between the 1993 conditions and the ultimate pit conditions (year 2006) should be greater than the actual difference between the No Action Alternative and Proposed Action.

Based on the groundwater simulations, dewatering during pit excavation under the Proposed Action would lower groundwater levels 50 to 200 feet in the bedrock area surrounding the pit. The greatest water level change is expected to occur beneath the ridge west of the pit. Flow paths in the groundwater regime would change due to the altered cone of depression. Comparison of the two simulated groundwater surfaces indicate the groundwater divide shifting to the west (Map IV-6) 500 to 1,000 feet. Flow paths from the 1993 conditions and the Proposed Action condition are illustrated on Map IV-4 and Map IV-7. Groundwater profiles through the pit area are presented in Figure IV-1. Because of the shift in the groundwater divide, groundwater formerly flowing through the bedrock unit to the west is captured by the pit. Model results in the Quaternary deposits exhibit water level declines immediately downgradient of the pit. These declines would result from the absence of pit area bedrock outflow.

Model simulation results for the predicted pit inflows are presented in Table IV-4. Table IV-4 represents only the groundwater component of the pit inflow. Predicted pit inflow for the year 2006 (the ultimate pit simulation) is 50 gpm. Higher pit inflows are evident prior to year 2006 (i.e., 2002 and 2004). These higher flows most likely result from steeper hydraulic gradients. Comparison of pit inflow estimates from Table IV-4 for 1996 to 2006 yields an average 20 gpm increase in pit groundwater inflow. This estimate represents the average incremental groundwater flow lost to the regional groundwater system for the duration of the Proposed Action pit expansion.

A water balance model (Hydrometrics 1995) accounts for surface water recharge to the pit. The simulations assume no pit run-on component (i.e., no surface water flows into the pit from outside the pit boundary). A summary of the pit water balance is presented in Table IV-5. Surface water inflow to the pit includes snowmelt, runoff, and direct precipitation. Water balance simulations for the pit (year 2006) estimate a surface water recharge of 53 gpm. Combined with the groundwater contribution, the total inflow to the pit resulting from both groundwater and surface water sources is estimated to be 102 gpm at the end of the Proposed Action.

With the increase in the pit drawdown the potential for impacts to local springs becomes greater under the Proposed Action than under the No Action Alternative. The springs with the greatest potential for impacts resulting from the pit dewatering, are the Steppan and the Steppan Original Springs (see Section IV.B.1.b). During mining operations, there exists the potential for the pit's cone of depression to intercept the flow to the Steppan and Steppan Original Springs. A the worst-case scenario (i.e., a direct connection with the pit) can be evaluated by assuming these two springs cease to flow. Based on average spring flows, a loss of about 2 gpm in the local surface water resources would result. The pit's cone of depression also has the potential to reduce the bedrock flow to the colluvium and alluvium units which contain the Rattlesnake and Bunkhouse Springs. However these springs are believed to receive recharge from runon, infiltration and regional flow from the alluvial aquifer. Consequently, spring flows may be reduced but it is unlikely they would cease to flow. Beaver and Sheep Rock Springs are least likely to be impacted due to their distance, upgradient location and recharge contributions from runon and infiltration. The unnamed spring in St. Paul Gulch also is unlikely to be impacted because of its location on the opposite side of the groundwater divide with respect to the pit.



Legend

5100 —— Potentiometric Contour Line – Ultimate Pit Simulation Under Dewatered Conditions (2006)

▬ Ultimate Pit Boundary

— Profile Alignment

• Direction of Ultimate Flow

NORTH

GOLDEN SUNLIGHT MINE EXPANSION

MAP IV-7
ULTIMATE PIT SIMULATION
SEASON 2006

SOURCE: HYDROMETRICS [illegible] SHEET 2

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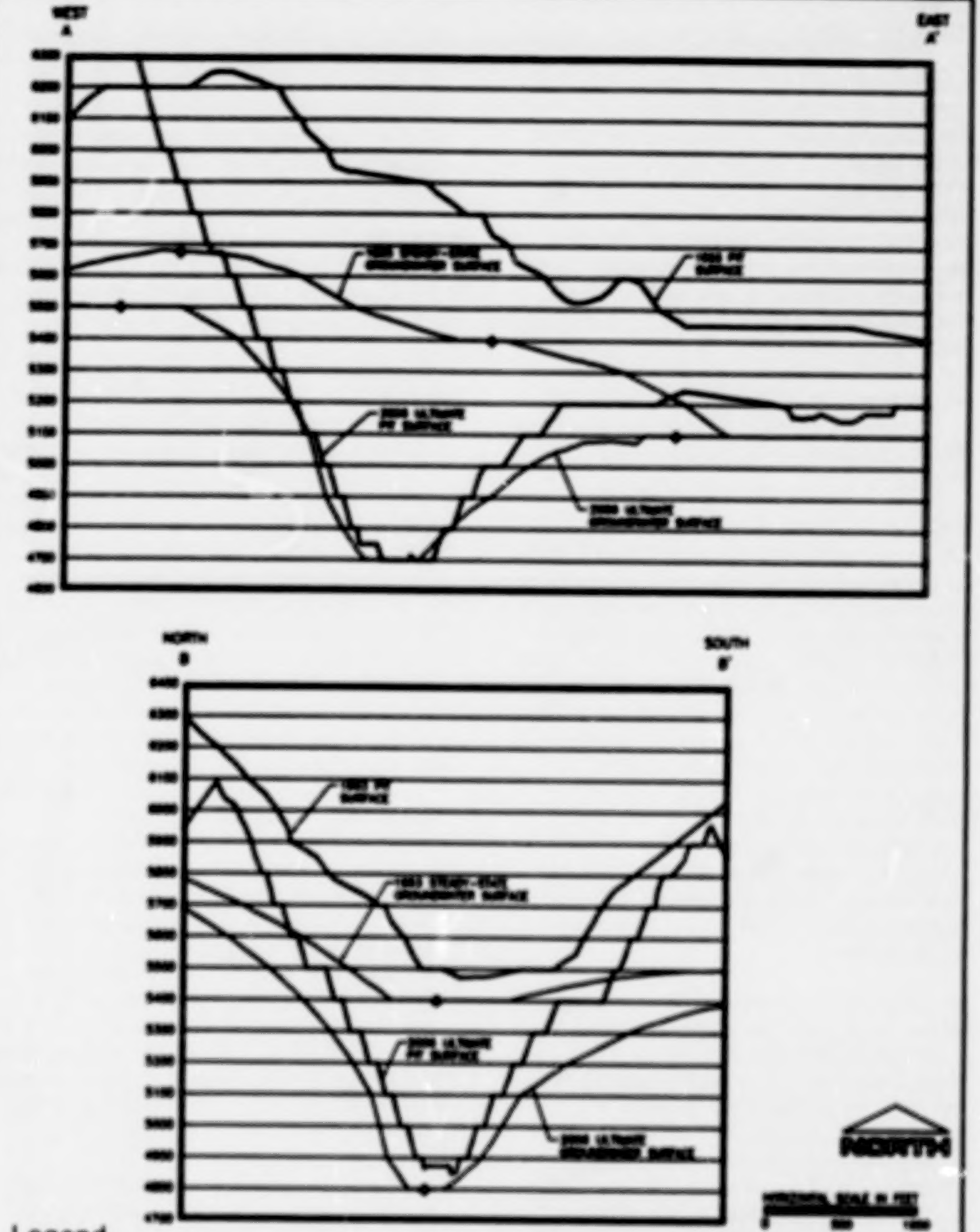

Legend

♦ WATER TABLE

NOTE: All elevations are relative to OSM datum. Subtract 91.5 feet to convert elevations to USGS mean sea level datum.

GOLDEN SUNLIGHT MINE EXPANSION

FIGURE IV–1
PIT AND WATER SURFACE PROFILE
WEST–EAST AND NORTH–SOUTH

SOURCE: GENERATED FROM HYDROMETRICS 1995 SHEET 2

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Open Pit Impacts to Long-Term Water Quality

The long-term impacts of ARD related to the open pit are essentially the same as the operational impacts. All flows must be treated at the higher pit inflow rates expected for the Proposed Action as compared to the No Action Alternative. All water that drains into the pit would eventually be routed to the permanent water treatment plant. No untreated pit water would be discharged to existing drainages. Because all groundwater intercepted by the pit would be routed to the water treatment plant, groundwater quality would not be impacted by the pit expansion.

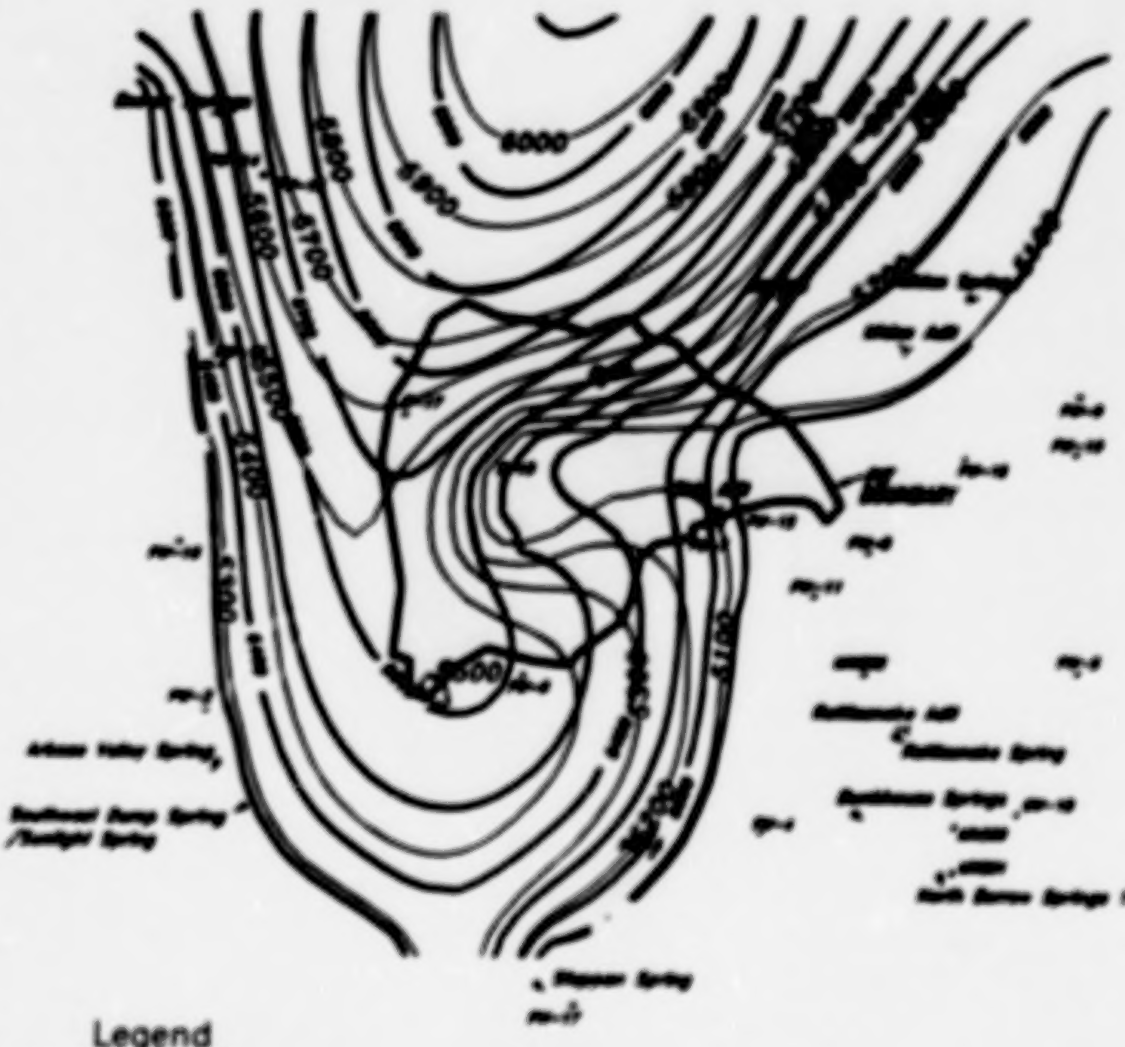
Open Pit Impacts to Long-Term Water Quantity

Under the Proposed Action, the pit would be allowed to partially fill with water following the end of mining. It is estimated that groundwater discharge from the pit would occur when the pond reaches an elevation of approximately 5,050 feet (Hydrometrics 1995). Pit water would be removed at a rate sufficient to maintain the pit as a sink (i.e., at or below 5,050 feet). This would maintain a pit pond size of approximately 37.6 acres. Run-on to the pit would be managed by collection channels around the perimeter of the pit, and thereby routed to adjacent drainages. Channels and control structures, built to address appropriate design features such as stability, capacity, and erosion protection, would be effective in controlling run-on/runoff.

Groundwater model simulations were conducted of the ultimate pit with ponding elevations at 4,900 feet, 5,050 feet and 5,175 feet to evaluate the potential changes in groundwater inflow to the pit as it fills (Hydrometrics 1995). Simulation results estimate groundwater inflow to the pit pond at approximately 47 gpm and a discharge out of the pit pond of approximately 2 gpm for the pond water surface elevation at 5,050 feet. The same pit water balance model discussed previously in the operational impact section was used to account for direct precipitation, run-off, snow melt and evaporation in addition to the groundwater contribution. Table IV-5 indicates that the pit pond elevation would reach the critical elevation of 5,050 feet in approximately 30 years. At that time total inflow to the pit would be approximately 116 gpm, seepage loss is estimated at approximately 2 gpm and evaporation loss at approximately 62 gpm. In order to maintain the pond elevation at 5,050 feet pumps would have to pump out an amount equal to the total inflow minus the 62 gpm of evaporation (approximately 54 gpm). This water would report to the permanent water treatment plant for processing and discharge as described in the No Action Alternative.

As discussed in Section IV.B.1.b, Open Pit, under the No Action Alternative, discharge at springs and seeps can be impacted by depressed water levels. Groundwater contours estimated by the groundwater model simulation of the pit pond at 5,050 feet are presented in Map IV-8 and Map IV-9. In the vicinity of Beaver Springs, model results indicate depressed groundwater levels when compared with the 1993 steady state conditions (Map IV-8). The depression is less for the operational condition because the system has not reached equilibrium at the end of pit excavation. Inflow estimates where the water surface is maintained at 4,700 feet are based upon a transient simulation in which that water surface elevation is maintained for the active pit operational period at the 4,700-foot elevation (2 years) (Hydrometrics 1995). Inflow estimates based upon the Proposed Action reclaimed pond elevation (5,050 feet) represent the system 30 years after the end of pit excavation, hence the system is at or much closer to equilibrium. While the potentiometric surface in the vicinity of Beaver Springs is only a rough estimate (because there are no groundwater wells in the area from which to calibrate the modeling), the simulations indicate that the long-term impacts to the springs may not be evident for several decades .

Long-term impacts under the Proposed Action to springs are expected to be slightly greater than but similar to the long-term impacts associated with the No Action Alternative. This is due to the slightly lower pit water surface (5,050 versus 5,100) elevation.



Legend

5100 ▬▬ Potentiometric Contour Line – Steady-State Simulation of As-Built Pit ([illegible])

5100 —— Potentiometric Contour Line With Pit Water Surface at [illegible]

PZ-12 Monitoring Well Number and Location

Adit

Spring

Ultimate Pit Boundary

NOTE: All elevations are relative to [illegible] datum. Subtract 91.5 feet to convert elevations to USGS mean sea level datum.

GOLDEN SUNLIGHT MINE EXPANSION

MAP IV-8

PIT SURFACE WATER ELEV=[illegible]' VS
1985 FLOW SIMULATION

SOURCE: HYDROMETRICS [illegible] SHEET 1, [illegible]

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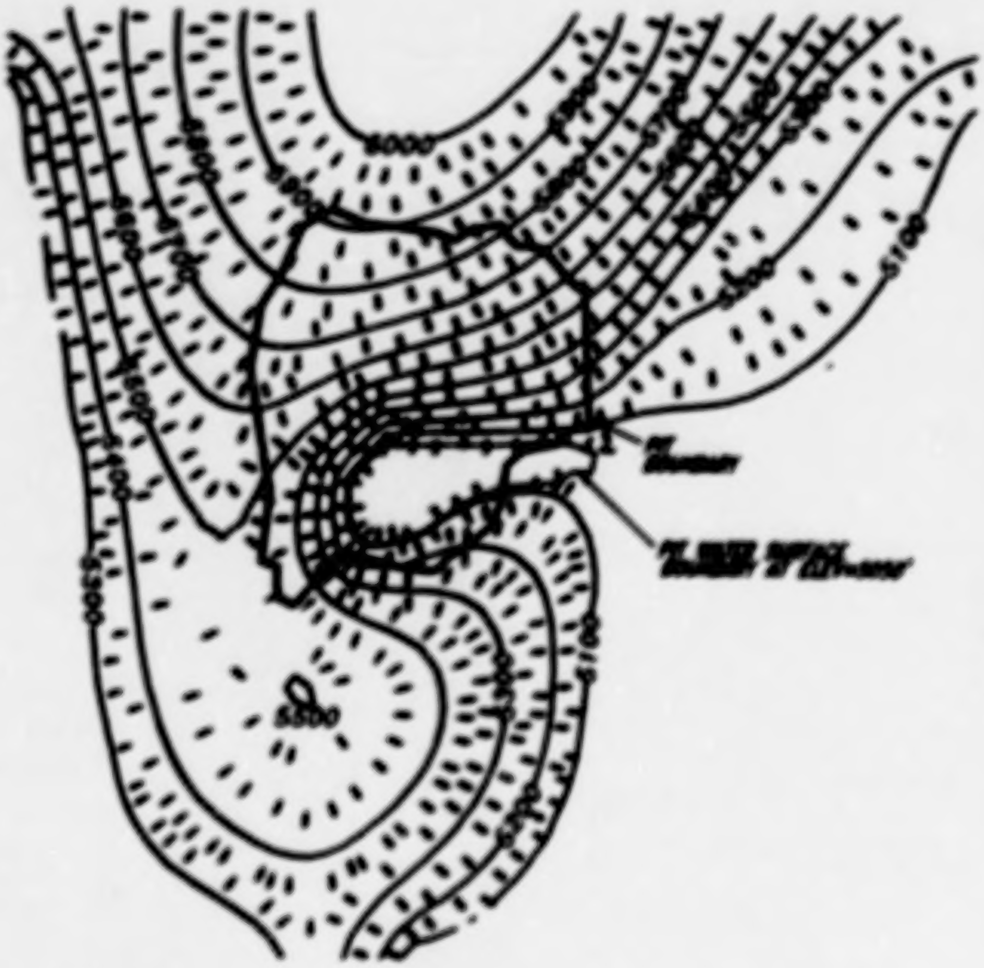

Legend

5100 —— Potentiometric Contour Line - Steady-State Simulation w/ Pit Water Surface Elev=5050'

—— Ultimate Pit Boundary

- Direction of Steady-State Flow

GOLDEN SUNLIGHT MINE EXPANSION

MAP IV-9

FLOW SIMULATION

PIT WATER SURFACE ELEV=5050'

SOURCE: HYDROMETRICS [illegible]

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Summary of Open Pit Impacts to Water Quality and Quantity

Under the Proposed Action the impacts to water resources associated with open pit operation are potential reductions in discharge from some springs due to lowered groundwater levels associated with pit dewatering. A worst-case scenario would result in the Steppan and Steppan Original Springs ceasing to flow, thereby reducing local surface water resources an average of 2 gpm. Other springs on the site may experience some impacts but are expected to continue to flow.

Long-term impacts to water resources associated with the open pit are:

- Potential reduction in discharges from some springs is slightly greater than but similar to the No Action Alternative, from lowered groundwater levels associated with pit dewatering. These potential impacts could be addressed by Mitigation Measure W-1 (see Section IV.P, Potential Mitigation and Monitoring);
- Water in the pit pond would be impacted by ARD. However, pit water would be treated before discharge to the groundwater system, so no impacts to water quality are anticipated. Mitigation Measure W-6 (see Section IV.P, Potential Mitigation and Monitoring) addresses the treatment plant capacity considerations with regard to the potential for ARD inflows to the pit that are greater than expected.

Pit groundwater discharge to adjacent hydrostratigraphic units is not anticipated because the pit pond would be maintained at an elevation no greater than 5,050 feet. Mitigation Measure W-2 (see Section IV.P, Potential Mitigation and Monitoring) addresses greater than expected pit water levels.

IV.B.2.c Tailings Impoundment

Water resources issues for the tailings impoundments are the same as for the No Action Alternative, and include evaporative losses of water resources, and potential release of cyanide, and, later, ARD into the environment. The Proposed Action would result in approximately 27.3 million tons of additional tailings being deposited in Tailings Impoundment No. 2.

Tailings Impacts to Water Quality and Quantity During Mining Operations

Although additional tailings materials would be deposited in Tailings Impoundment No. 2, incremental impacts to groundwater quality or quantity would be minimal because the facility is lined. There is a somewhat greater risk associated with liner failure under this alternative compared with the No Action Alternative because of the higher loading and hydraulic heads on the liner. However, the likelihood of extensive liner ruptures occurring during the operational life of the mine is considered low.

Surface water would be diverted using the same facilities as in the No Action Alternative. Impacts of tailings impoundment operation for the Proposed Action would be the same as for the No Action Alternative.

Tailings Impacts to Long-Term Water Quality and Quantity.

The proposed reclamation cover for the tailings impoundments differs from the No Action Alternative. Under the Proposed Action, the reclamation cover would utilize 24 inches of soil placed upon 24 inches of local borrow. Numerical modeling (Schafer and Associates 1996) form the basis for the effectiveness of the proposed reclamation cap. The infiltration modeling originally submitted in the permit application modeled the system for only 1 year with the result that negligible infiltration would occur. Subsequent to the 1-year simulation, longer simulations were run for 20 years and 50 years. Results from the long-term, (50-year average), predict a long-term infiltration rate of 0.25 inch per year. This effluent may be ARD in character and possibly contain cyanide concentrations in the short-term. Because of the infiltration associated with the proposed reclamation cap, seepage from Tailings Impoundment No. 1 would continue to occur even after the tailings have consolidated. Low quality effluent would be intercepted by the groundwater pumpback system and routed to the permanent water treatment plant.

Groundwater impacts would be negligible under Tailings Impoundment No. 2 as long as the liner system remains intact. Although localized ruptures in the HDPE liner are likely to occur over the long-term, the HDPE liner is underlain by compacted clay which should contain most isolated leaks. Leaks in the primary liner under the double-lined east reclaim basin would be detected and contained by the leak detection system if appropriate monitoring is maintained. Leaks in the impoundment liner could be detected and controlled by appropriate monitoring/pumpback well systems, as described under Section IV.P, Potential Mitigation and Monitoring, Measure W-8. Uncontrolled leakage from Tailings Impoundment No. 2 would likely result in greater impacts to downgradient domestic and agricultural beneficial uses (shown on Map IV-2) than the No Action Alternative because of the increased volume of tailings. These impacts would occur over a longer duration, as well.

The total amount of water in Tailings Impoundment No. 2 would be gradually reduced through the recycling and evaporation process until the rate of consolidation and drainage is greatly reduced. Considering the overall reduction in the rate of seepage with time, it is anticipated that unavoidable groundwater impacts in the immediate vicinity of the impoundment also will diminish with time.

Tailings Impoundment No. 2 would be reclaimed after dewatering by spray evaporation is substantially complete. Long-term infiltration seepage through the proposed reclamation cover would be collected on the liner, and would report to the permanent water treatment plant. Long-term additional inflow to the treatment plant beyond that for the No Action Alternative is estimated to be approximately 5 gpm.

The increase in tailings volume would proportionately increase the volume of water that would be treated during the long-term. Since all of the infiltrating water would be treated, no water quality impacts are anticipated. Surface water/groundwater quantities would increase proportionately over the No Action Alternative due to the increased volume discharged from the treatment plant.

Summary of Tailings Impacts to Water Quality and Quantity

The operational impacts for the tailings impoundments with respect to ARD would be similar to those for the No Action Alternative. The Tailings Impoundment No. 1 pumpback system and Tailings Impoundment No. 2 liner collection system will ensure that water quality impacts are confined to the immediate vicinity of the impoundments. An additional volume of water will be lost through spray evaporation dewatering under the Proposed Action, in comparison with the No Action Alternative.

Over the long-term, potential leakage from the Tailings Impoundment No. 2 HDPE liner is likely to occur, but the main liner under the impoundment is underlain by compacted clay which should contain most small, isolated leaks. Uncontained leakage would likely impact downgradient beneficial uses. Leakage, and impacts, would diminish with time as the tailings are dewatered through evaporation, but the overall time to dewater and the potential volume of any leakage would be greater for this alternative than under the No Action Alternative. Potential monitoring and mitigation measures for liner leakage are described in Section IV.P, Potential Mitigation and Monitoring, Measure W-8.

The tailings cover under the Proposed Action allows a predicted long-term infiltration rate of 0.25 inch per year, whereas the No Action Alternative capping exhibited a negligible predicted net infiltration. This infiltration will result in increased water quantity (on the order of 10 gpm or less) to be processed during the long-term by the permanent water treatment plant.

IV.B.2.d Mill Area, Permanent Water Treatment Plant, and Support Facilities

Mill Area, Permanent Water Treatment Plant, and Support Facilities Impacts to Water Quality and Water Quantity During Mining Operations

No changes are proposed for the mill area, permanent water treatment plant, and support facilities under the Proposed Action. The impacts of the mill area, permanent water treatment plant, and support facilities during operation for the Proposed Action would be the same as for the No Action Alternative, except they will last until the year 2006 rather than 1997.

Permanent Water Treatment Plant Impacts to Long-Term Water Quantity and Water Quality

Estimated inflows, long-term impacts, and mitigation measures associated with perpetual water treatment are the same as for the No Action Alternative.

IV.B.3 Return Diversion Alternative

IV.B.3.a Waste Rock Dumps

Concerns for impacts to water resources associated with the waste rock dumps are similar to the Proposed Action. Under this alternative, runoff from the Sheep Rock Creek drainage would be routed to the east and then to the south around the East Waste Rock Dump, ultimately discharging back into Sheep Rock Creek, as described in Chapter II (Section II.B.3.a), and illustrated on Map II-2. The channel would be designed to handle flows equaling one-half of the PMF.

This routing alignment would maintain surface water runoff from Sheep Rock Creek within its drainage basin. This alternate alignment contrasts with the Proposed Action diversion which routes Sheep Rock Creek runoff to the Conrow Creek drainage. Conrow Creek currently receives no runoff from the permitted project area. This alternative would eliminate the potential for impacts to water resources in Conrow Creek which exist under the Proposed Action.

Waste Rock Impacts to Water Quality During Mining Operations

Under the conceptual diversion channel design, Sheep Rock Creek flows would be excluded from contact with the East Waste Rock Dump. Assuming the final design meets the stated design criteria and the channel is built according to plans and specifications, the diversion channel would prevent Sheep Rock Creek flows up to the one-half PMF from contacting the dump. Failure of the diversion channel structure could result in storm water contacting an active or reclaimed dump surface and provide a mechanism for ARD. Scheduled operational inspections and maintenance would minimize the potential for structural failure of the channel due to events less than the one-half PMF design flow.

The potential surface water quality impacts on Conrow Creek associated with the Proposed Action would be eliminated with this alternative. However, the 3,100-foot length of the unnamed tributary to Sheep Rock Creek that would convey diverted flows to Sheep Rock Creek could experience increased erosion, as this is a smaller channel than upper Sheep Rock Creek. Mitigation Measure W-3 addresses these impacts. Other surface water quality impacts are anticipated to be the same as for the Proposed Action.

Waste Rock Impacts to Long-Term Water Quality

Waste rock dumps would be reclaimed in the same manner as for the Proposed Action. Since the dump footprints would be essentially unaltered, pumpage rates for long-term ARD control by the groundwater capture system would be the same as for the Proposed Action, which are summarized on Table IV-6. Both alternatives require the maintenance of a diversion channel and associated structures to route the flows of Sheep Rock Creek around the East Waste Rock Dump. As discussed under operational impacts, this alternative eliminates

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impacts to the water resources of Conrow Creek which exist under the Proposed Action. However, the unnamed tributary to Sheep Rock Creek could experience increased erosion. All other impacts to surface water, to groundwater, and to beneficial uses of water remain the same as were described for the Proposed Action.

Waste Rock Impacts to Water Quantity

Surface water in Sheep Rock Creek currently infiltrates into the ground and serves as a recharge source to the groundwater system. Under both this alternative and the No Action Alternative, runoff from Sheep Rock Creek remains within its drainage basin where it infiltrates and is a source of groundwater recharge. Therefore, impacts to surface water and groundwater quantity under this alternative are the same as the No Action Alternative.

Summary of Waste Rock Impacts to Water Quality and Quantity

This alternative eliminates the potential impacts to Conrow Creek that would occur under the Proposed Action. However, increased erosion could occur in the unnamed tributary to Sheep Rock Creek (addressed in Mitigation Measure W-3). As long as the diversion channel and associated structures function to the intent of their design criteria, other impacts to water quality and quantity would be the same as those expected for the Proposed Action. If the one-half PMF is exceeded, erosion of the diversion channel and associated structures could occur. This, in turn could expose materials in the East Waste Rock Dump to erosion or infiltration. However, such erosion would occur only as the result of a very rare natural event. The design criteria (one-half PMF event) provides reasonable assurance against erosion of the diversion channel, and no mitigation measures are deemed necessary.

IV.B.3.b Open Pit

Operational and long-term impacts to water resources from the open pit are the same as discussed for the Proposed Action.

IV.B.3.c Tailings Impoundments

Operational and long-term impacts on water resources related to the tailings impoundments are the same as discussed under the Proposed Action.

IV.B.3.d Mill Area, Permanent Water Treatment Plant, and Support Facilities

Operational and long-term impacts related to the mill area and support facilities on water resources are the same as discussed under the Proposed Action.

IV.B.4 Divided Dump Alternative

IV.B.4.a Waste Rock Dumps

Under this alternative the East Waste Rock Dump would be divided to accommodate the natural drainage of Sheep Rock Creek. During operation, a land bridge would be constructed across the Sheep Rock Creek drainage to accommodate access to the waste rock dump. All other aspects of the mine operation, and concerns for impacts to water resources, would be the same as described for the Proposed Action.

Waste Rock Impacts to Water Quality and Quantity During Mining Operations

The Sheep Rock Creek drainage alignment and its watershed boundary would be kept intact under this alternative, with the waste rock dumps configured in such a way as to remain out of the drainage. Construction of the land bridge would result in short-term disturbance to the Sheep Rock Creek streambed in the vicinity of the bridge. Impacts to water resources would be minimized by routing storm water to vegetated areas and using hay bales, silt fences and other erosion control practices to limit erosion and sediment transport. A culvert would be constructed to route Sheep Rock Creek storm flows through the land bridge.

Under this alternative any drainage from dump areas B1 and B2 (see Map II-3) would impact drainage basins that have not been previously impacted by mining operations. Alternative Dump B1 area would drain into a tributary of Conrow Creek. ARD from this dump also would impact the groundwater in this drainage. However, the underlying foundation materials in this area have potentially high neutralization capacity, and it is unlikely that ARD impacts would be detected except in the immediate vicinity of the dump, as was discussed in Section IV.B.1.a.

__Waste Rock Impacts to Long-Term Water Quality and Quantity__

During reclamation, the land bridge and its associated fill materials and culvert, would be removed from the Sheep Rock Creek streambed. Following reclamation, long-term impacts to surface water and groundwater quantity and quality, and to beneficial uses of water would be generally the same as those discussed under the Proposed Action Alternative. In general, the overall magnitude of ARD production would be about the same, but the relative degree of impacts on the west side would be greater if the dump configuration chosen allows for more waste rock placement on the West Waste Rock Dump. The degree of ARD impacts on the west side of Bull Mountain also would be greater under this circumstance.

However, the ARD-related impacts to groundwater quality in the immediate vicinity of the dumps, as evaluated by estimated metals concentration ranges shown on Table IV-3, is the same for this alternative as for the Proposed Action. The relatively small incremental increases in dump footprint areas and infiltration do not have detectable effects on the extent and timing of ARD-associated metals concentrations within the inherent range of error of the ARD fate and transport simulation (see Appendix J).

The groundwater capture system to control ARD would have to be extended to accommodate the longer periphery around dump toes. Depending on the dump configuration used, the pumpage rates for this alternative are estimated to range as summarized on Table IV-7.

These pumpage rates are greater than the rates that were predicted for the Proposed Action because of the extended footprints of the dumps.

Under the Divided Dump Alternative, the East Waste Rock Dump could extend into the Conrow Creek drainage. No known existing beneficial uses have been identified in Conrow Creek within a reasonable downgradient proximity to the waste rock dump. The West Waste Rock Dump could extend further south under this alternative than under the Proposed Action. Based on the West Waste Rock Dump footprint shown on Map II-3, capture wells could be as close as 2,200 feet from the domestic and agricultural beneficial use area identified on Map IV-2. However, groundwater wells in this area are likely to be completed in the Jefferson alluvial aquifer, and therefore are unlikely to be impacted by pumping drawdown from the proposed bedrock fracture-flow capture system.

Table IV-7

Estimated Pumpage Rates for Conceptual Groundwater Capture System
Divided Dump Alternative

Waste Rock Dump	Pumpage Rate (gpm)	Capture Efficiency Range
West		
(no west dump expansion)	50	80 to 100%
(with west dump expansion)	80	
East (Contingency Only)	235	98-100%

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Summary of Waste Rock Impacts to Water Quality and Quantity

The alternatives which use a Sheep Rock Creek diversion structure (the Proposed Action and the Return Diversion Alternative), would rely in part, on lined surface water diversions to separate surface water flows from waste rock. The divided dump eliminates reliance on a mechanical barrier to prevent surface water contact with reactive sulfide waste and thus represents a reduced potential long-term impact in this regard. Other impacts to surface water, to groundwater, and to beneficial uses of water remain the same as were described for the Proposed Action.

IV.B.4.b Open Pit

Operational and long-term impacts on water resources from the open pit are the same as discussed under the Proposed Action.

IV.B.4.c Tailings Impoundments

Operational and long-term impacts related to the tailings impoundments on water resources are the same as discussed under the Proposed Action.

IV.B.4.d Mill Area, Permanent Water Treatment Plant, and Support Facilities

Operational and long-term impacts related to the mill area, permanent water treatment plant, and support facilities on water resources are the same as discussed under the Proposed Action.

IV.B.5 3:1 Slope Alternative

IV.B.5.a Waste Rock Dumps

Under the No Action Alternative and Proposed Action, waste rock dumps would be reclaimed by reducing most slopes to 2:1. Under this alternative all waste rock dump slopes would be reduced to 3:1. The concerns for water resources impacts are the same as for the Proposed Action.

Waste Rock Impacts to Water Quality and Quantity During Mining Operations

During operation, impacts from unreclaimed dumps would be the same as those discussed for the Proposed Action.

Waste Rock Impacts to Long-Term Water Quality and Quantity

As dumps are reclaimed, dump slopes would be reduced to 3:1. In general, milder gradients generate less runoff than steeper gradients. The decrease in runoff is accounted for by an increase in infiltration and/or evapotranspiration. Therefore a decrease in runoff compared with the No Action and Proposed Action resulting from the reduced slope can be expected. The reduced slope may lessen erosion and thereby reduce sediment transport.

The numerical simulation provided in Appendix J indicates that groundwater quality may be slightly more degraded under this alternative, than for reclamation with 2:1 slopes only. Water balance modeling results (GSM 1995b) indicate seepage rate is not significantly affected by slope angle (assuming the proposed reclamation cover design). However, the increased surface area (12 percent) associated with flatter slopes would allow additional quantities of water to infiltrate into dumps, resulting in a larger recharge of ARD into the aquifer.

The incremental impacts appear in the predicted ARD (i.e., sulfate) concentrations and reduced time to impacts on the west side of the mine site (see results plotted in Appendix J). (Again, the model output should be viewed as a tool for comparing alternatives only, and the numerical results are considered very approximate.) The 3:1 versus 2:1 alternatives appear to result in nearly identical ARD concentrations and timing of impacts for the East Waste Rock Dump.

The ARD-related impacts to groundwater quality in the immediate vicinity of the dumps, as evaluated by estimated metals concentration ranges shown on Table IV-3, is the same for this alternative as for the Proposed Action. The relatively small incremental increases in dump footprint areas and infiltration rates do not have detectable effects on the extent and timing of ARD-associated metals concentrations within the inherent range of error of the ARD fate and transport simulation (see Appendix J). Likewise, the groundwater capture-system model (see Appendix L) cannot interpret a distinction between this alternative and the Proposed Action with regard to the conceptual interception well system requirements. The pumpage rates for the groundwater capture system are estimated to be approximately the same as for the Proposed Action, as shown on Table IV-6.

Summary of Waste Rock Impacts to Water Quality and Quantity

The groundwater recharge quality would be expected to experience greater ARD impacts sooner on the west side of the mine site under this alternative, as compared to the Proposed Action. Also, if infiltration into waste rock dumps increases, there could be increased quantities of ARD-containing surface waters from increased dump seepage that does not immediately infiltrate the ground surface below the West Waste Rock Dump (see Appendix J). However, these small incremental impacts are relatively insignificant when compared with all the other alternatives on the basis of ultimate concentrations and timing for metals impacts. Impacts to beneficial uses of water remain the same as described for the Proposed Action.

IV.B.5.b Open Pit

Operational and long-term impacts related to the open pit on water resources are the same as discussed under the Proposed Action.

IV.B.5.c Tailings Impoundments

Operational and long-term impacts related to the tailings impoundments on water resources are the same as discussed under the Proposed Action.

IV.B.5.d Mill Area, Permanent Water Treatment Plant, and Support Facilities

Operational and long-term impacts related to the mill area, permanent water treatment plant, and support facilities on water resources are the same as discussed under the Proposed Action.

IV.B.6 No Pit Pond Alternative

IV.B.6.a Waste Rock Dumps

Operational and long-term impacts related to the waste rock dumps on water resources are the same as discussed under the Proposed Action.

IV.B.6.b Open Pit

Under the Proposed Action reclamation of the pit would allow the pond to partially fill with water up to an elevation of 5,050 feet. Under this alternative, reclamation of the pit would provide for a sump below the reclaimed pit bottom to collect surface water and groundwater that enters the pit. Water collected in the sump would be routed to the permanent water treatment plant. In order to provide safe access to the pit floor (for maintenance of the dewatering system) the pit would be partially backfilled with waste rock to the 4,800-foot elevation. Potential impacts to water resources are the same as for the Proposed Action.

Open Pit Impacts to Water Quality and Quantity During Mining Operations

This alternative affects only the reclamation components of the Proposed Action. Therefore, operational impacts associated with this alternative remain the same as the Proposed Action.

Open Pit Impacts to Long-Term Water Quality

Since all water pumped from the pit sump would be routed to the permanent water treatment plant, no additional impacts to water quality would be expected.

Open Pit Impacts to Long-Term Water Quantity

Impacts associated with pumping water from the pit sump focus on the quantity of water to treat and discharge, and the quantity of sludge that would be produced as a by-product of water treatment. A summary of the pit water balance model (Hydrometrics 1995) which accounts for total inflows and outflows is presented in Table IV-5. Complete dewatering of the pit to the pit floor (4,800 feet) would require perpetual removal of approximately 102 gpm. Under the Proposed Action and other alternatives, total inflows when the pit is ponded at an elevation of 5,050 feet are estimated at approximately 54 gpm (see Table IV-5). Consequently, water treatment requirements would be greater under this alternative as compared to the other alternatives.

As discussed in Section IV.B.1.b, Open Pit, under the No Action Alternative, discharge at some springs and seeps could be reduced from the expanding cone of depression resulting from the pit dewatering. Previous discussion (see Section IV.B.2.b) indicated steady state conditions, approached after many years, result in lower groundwater levels than those predicted for lower elevations for a lesser duration. If the pit water level is maintained in perpetuity at 4,800 feet, the cone of depression could expand beyond the operational cone of depression. This would result in locally lower groundwater elevations than would occur under operational conditions.

As stated previously, accurate quantification of incremental changes in spring discharge is not possible. However, it is anticipated that change in groundwater levels and impacts to springs would be maximized under this alternative due to the magnitude and infinite duration of the pit drawdown. Consequently, long-term impacts to spring flows are anticipated to be greater under this alternative than the Proposed Action or other alternatives.

Summary of Open Pit Impacts to Water Quality and Quantity

No impacts would be anticipated to water quality beyond that expected for the Proposed Action. However, water quantities could be impacted due to pumping of the pit sump. This alternative will likely have the greatest impact on spring flows. These impacts are addressed by Mitigation Measure W-1 (in Section IV.P, Potential Mitigation and Monitoring). Furthermore, inflow to the permanent water treatment plant would be increased from approximately 54 gpm to 102 gpm. Mitigation Measure W-6 addresses potential water treatment plant inflows that exceed the proposed plant design capacity.

IV.B.6.c Tailings Impoundments

Operational and long-term impacts related to the tailings impoundments on water resources are the same as discussed under the Proposed Action.

IV.B.6.d Mill Area, Permanent Water Treatment Plant, and Support Facilities

Inflows to the permanent water treatment plant would increase by about 48 gpm over that estimated for the Proposed Action. The rate of sludge production by the treatment plant also would increase proportionally, thus increasing sludge storage capacity needs. Operational and long-term impacts related to the mill area and support facilities on water resources are the same as discussed under the Proposed Action.

IV.B.7 Partial Backfill Alternative

IV.B.7.a Waste Rock Dumps

The concerns for water resources impacts would be the same as for the Proposed Action. Under this alternative, the surface area covered by the waste rock dumps would be 82 acres less than for the Proposed Action. The materials omitted from the waste rock dumps under this alternative would be placed in the pit as partial backfill.

Waste Rock Impacts to Water Quality and Quantity During Mining Operations

During operation, impacts from unreclaimed dumps would be the same as those discussed for the Proposed Action.

Waste Rock Impacts to Long-Term Water Quality and Quantity

Impacts to water quality would be expected to decrease compared to the Proposed Action because of the decreased waste rock dump area available for infiltration and ARD production. The waste rock material placed in the pit would remain subject to infiltration, and ARD production would still occur. Overall, a net reduction in ARD production associated with infiltration through waste rock would be expected because of the diminished surface area exposed to direct precipitation and infiltration.

However, the ARD-related impacts to groundwater quality in the immediate vicinity of the dumps, as evaluated by estimated metals concentration ranges shown on Table IV-3, is the same for this alternative as for the Proposed Action. The relatively small incremental decreases in dump footprint areas and infiltration rates do not have detectable effects on the extent and timing of ARD-associated metals concentrations within the inherent range of error of the ARD fate and transport simulation (see Appendix J). Likewise, the groundwater capture-system model (see Appendix L) cannot interpret a distinction between this alternative and the Proposed Action with regard to the conceptual interception well system requirements. The pumpage rates for the groundwater capture system are estimated to be approximately the same as for the Proposed Action, as summarized on Table IV-6 because the dump footprint areas would not be substantially different under this alternative.

Impacts to, and mitigation measures for, water resources and beneficial uses of water remain the same as were described for the Proposed Action.

IV.B.7.b Open Pit

Open Pit Impacts to Water Quality and Quantity During Mining Operations

This alternative affects only the reclamation components of the Proposed Action. Therefore, operational impacts associated with this alternative remain the same as the Proposed Action.

Open Pit Impacts to Long-Term Water Quality and Quantity

Under the Partial Backfill Alternative, reclamation of the pit would include backfilling the pit to the daylight level, covering all sulfide-bearing rock and reclaiming the upper pit slopes at 2:1. Figure II-4 shows the final pit configuration under the Partial Backfill Alternative.

General fill material would consist of waste rock from the East and West Waste Rock Dumps. All acid-producing rock within the pit would be capped with oxide rock and soil. In total, approximately 254 acres of the pit would be capped. Approximately 187 acres of sloped areas in the backfilled pit would be capped with 26.8 inches of oxide rock followed by 26.8 inches of soil and revegetated. Approximately 67 acres of flat areas in the backfilled pit would be capped with 24 inches of oxide rock followed by 24 inches of soil and revegetated. The water quality of the pit discharge is expected to be poor and therefore would have to be treated. Consequently, a pit dewatering system capable of maintaining the groundwater elevation in the pit to 5,050 feet (contact of bedrock and colluvium) would be required. A series of wells constructed along the floor and/or lowermost benches of the pit would be utilized to accomplish the pit dewatering. The discharge lines would be manifolded into a common conveyance that reports to the permanent water treatment plant.

Based upon the estimated pit water balance for the ultimate pit configuration under the Proposed Action (see Table IV-5), an estimated maximum of approximately 47 gpm of water plus infiltration would have to be pumped in perpetuity in order to maintain the required water elevation. No infiltration estimates for the backfill and cover have been calculated. Using the Waste Rock Dump infiltration rate of 0.25 inch per year as a rough estimate, approximately 3 gpm of infiltration would occur. Consequently, the amount of water reporting to the permanent water treatment plant would be roughly equivalent to the Proposed Action.

Impacts to springs from the pit dewatering under this alternative are expected to be similar to the Proposed Action, where pit water elevations are maintained at or below 5,050 feet in elevation.

Summary of Open Pit Impacts to Water Quality and Quantity

Impacts are expected to be similar to those for the Proposed Action, since the pit water elevations will be maintained at the same level. Since the open pond surface would be eliminated, it is estimated that the pumping rate from the pit to the permanent water treatment plant would be 50 gpm. Mitigation Measure W-6 (see Section IV.P, Potential Mitigation and Monitoring) addresses potential inflows to the water treatment plant that exceed the proposed plant design capacity.

IV.B.7.c Tailings Impoundments

Operational and long-term impacts related to the tailings impoundments on water resources are the same as discussed under the Proposed Action.

IV.B.7.d Mill Area, Permanent Water Treatment Plant, and Support Facilities

Operational and long-term impacts related to the mill area, permanent treatment plant, and other facilities would be similar to the Proposed Action.

IV.C SOILS AND RECLAMATION

As noted in Section III.C, Soils and Reclamation, soils have developed from raw geologic materials over the past 10,000 years through various soil-forming processes. The result of this development is a soil system which has evolved a range of characteristics supporting the vegetation communities that have evolved concurrently with the soils of the region. Agency goals are to salvage and replace a sufficient volume of this weathered soil material, reflecting long-term edaphic development, that is required to achieve final reclamation and revegetation objectives. The soils will be replaced over a stable post-mining topography, conserving existing developed soil characteristics, in order to accelerate soil development.

Four tables have been prepared and are presented in this section to aid in depicting important characteristics of each alternative in terms of soils and reclamation. Table IV-8 depicts acreages requiring soil and cap rock application, by alternative. Table IV-9 presents information regarding cap rock material available for salvage and reapplication as well as volumes required for reclamation. Table IV-10 presents similar information regarding soil volume. Table IV-11 depicts acreages of 2:1 and 3:1 slopes which would be created on acid waste rock material under each alternative.

IV.C.1 No Action Alternative

Impacts to the soil resource will affect the physical, microbial, and chemical nature of the endemic soils, as well as the volumes available for reclamation. Erosion is a potential impact that also must be considered. A number of soil physical characteristics such as structure, texture, and rock fragment content (gravel-, cobble-, and rock-size geologic material) will be permanently modified through blending during soil salvage and replacement operations. Soil quality will not be negatively affected, in terms of reclamation potential, since only soils rated as suitable for reclamation by the MDEQ will be salvaged. In some cases, blending may be a positive benefit to revegetation potential since natural horizons of high coarse fragment content will be blended with horizons exhibiting lower coarse fragment volumes. This blending will result in a more amenable seedbed material overall, particularly in terms of reduced surficial erodibility. Compaction, most notably along haul road disturbances, will likely reduce the aeration, permeability, and water-holding capacity of impacted soils. The effects of compaction will be reduced to a short-term impact as a result of proposed grading and ripping activities as well as natural freeze-thaw cycles. The effects of compaction on soils overlying waste rock slopes may be more long-term, although slope revegetation activities to date have not indicated this type of detrimental effect.

Soil microbial populations also will change, with a potential overall loss of nitrifying-type species due to soil stockpiling activities. Soil microbial populations should reestablish over time through natural invasion from adjacent undisturbed areas. This is a generally accepted premise, based on observations of areas mined in the past in the Northern Great Plains, where stockpiled soil has been respread and revegetation has been successful. The revegetation success demonstrated on-site to date essentially confirms this general observation. This is considered to be a short-term, mitigable impact. No reduction in reclamation potential is expected as a result of impacts to soil microbial populations.

Soil chemical parameters will be permanently modified as a result of the proposed salvage program. Soil horizons will be mixed during salvage, resulting in a blending of characteristics, as compared to the soils in their natural state. Given that only soils rated as suitable for reclamation are proposed for salvage, blending should not result in the degradation of soil resources in terms of reclamation potential. Blending also may constitute a positive benefit to revegetation potential in terms of soil chemistry. Soils exhibiting excessive calcium carbonate contents may raise the pH of slightly acidic native soil

Table IV-6

Acreage of Disturbance Requiring Different Reclamation Covers by Alternative

Alternative	Total Disturbance	Waste Rock Dump Cap	Tailings Impoundment Cap	Total Acres Requiring Cap Rock[1]	Soil Cover Only
No Action	2,336	889	259	1,148	745
Proposed Action	2,964	1,190	349	1,539	987
Return Diversion	2,967	1,190	349	1,539	970
Divided Dump					
Minimum Scenario[2]	2,743	1,107	349	1,456	824
Maximum Scenario[3]	2,936	1,241	349	1,590	841
3:1 Slope	3,078	1,315	349	1,664	958
No Pit Pond	2,964	1,197	349	1,546	987
Partial Backfill	2,964	1,344	349	1,693	1,049

[1] Oxide rock capping is required in the waste rock dump areas. Neutral capping material is required in the tailings impoundment areas.

[2] The minimum disturbance scenario utilizes Area C2.

[3] The maximum disturbance scenario utilizes the land bridge, Area A, and Area B2.

Note: Totals may not add due to rounding.

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Table IV-9

Cap Rock Salvage Considerations by Alternative (in cubic yards)

Alternative	Maximum Cap Rock Volume Available from Salvage	Total Potential Cap Rock Volume Available[1]	Cap Rock Volume Required for Reclamation	Surplus (or Deficit) Cap Rock Volume
No Action	45,800	3,500,500	3,851,300	-350,800
Proposed Action	2,740,900	6,195,700	5,140,100	1,055,500
Return Diversion	2,740,900	6,195,700	5,140,100	1,055,500
Divided Dump				
Minimum Scenario[2]	2,740,900	6,195,700	4,895,300	1,300,400
Maximum Scenario[3]	2,740,900	6,195,700	5,346,500	849,200
3:1 Slope	2,740,900	6,195,700	5,514,200	681,500
No Pit Pond	2,740,900	6,195,700	5,162,100	1,033,600
Partial Backfill	2,740,900	6,195,700	5,692,200	503,400

[1] Total Available = Volume Available From Salvage + 3,454,800 yd^3 (Existing Cap Rock Stockpile Volume, to date)

[2] The minimum disturbance scenario utilizes Area C2.

[3] The maximum disturbance scenario utilizes the land bridge, Area A, and Area B2.

Note: Totals may not add due to rounding.

Source: Noel 1996.

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Table IV-10

Soil Salvage Considerations by Alternative (in cubic yards)

Alternative	Maximum Soil Volume Available from Salvage[1]	Total Potential Soil Volume Available[2]	Soil Volume Required for Reclamation[1]	Surplus (or Deficit) Soil Volume
No Action	762,000	3,831,800	4,154,700	-322,900
Proposed Action	3,305,500	6,375,300	5,622,300	753,000
Return Diversion	3,305,500	6,375,300	5,624,300	751,000
Divided Dump				
Minimum Scenario[3]	1,694,500	4,764,400	5,175,400	-411,000
Maximum Scenario[4]	2,887,200	5,957,000	5,727,500	229,500
3:1 Slope	3,461,700	6,531,500	5,924,500	607,000
No Pit Pond	3,305,500	6,375,300	5,644,300	731,000
Partial Backfill	3,305,500	6,375,300	6,245,100	130,200

[1] Includes all areas potentially to be disturbed under each alternative

[2] Total Available = Volume Available From Salvage + 3,069,800 yd^3 (Existing Soil Stockpile Volume, to date)

[3] The minimum disturbance scenario utilizes Area C2.

[4] The maximum disturbance scenario utilizes the land bridge, Area A, and Area B2.

Note: Totals may not add due to rounding.

Source: Noel 1996.

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Table IV-11

Acreage of 3:1 and 2:1 Slopes by Alternative (Acres)

Alternative	3:1 Slopes	2:1 Slopes	Total Sloped Acreage
No Action	118	339	457
Proposed Action	258	341	599
Return Diversion	258	341	599
Divided Dump Minimum Scenario[1] Maximum Scenario[2]	 258 186	 442 489	 700[3] 675[3]
3:1 Slope	824	0	824
No Pit Pond	258	341	599
Partial Backfill	258	494	752

[1] The minimum disturbance scenario utilizes Area C2.

[2] The maximum disturbance scenario utilizes the land bridge, Area A, and Area B2.

[3] Sloped areas are greater under the minimum scenario because Area C2 is a tall waste rock dump with relatively large sloped areas. Dumps on the east side (maximum scenario) contain predominantly flat areas.

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materials, thereby enhancing overall plant growth potentials (MDSL and BLM 1990). This excess also could potentially reduce soil fertility slightly and cause surficial crusting in extreme cases. The degree to which this will occur, however, cannot be estimated. Soil chemistry also will be modified through soil stockpiling as anaerobic conditions within the stockpiles develop. Soil chemical changes due to stockpiling are considered to be short-term and redeemable to a level commensurate with vegetation establishment following resoiling. The proposed soil sampling and fertilization program should adequately address soil chemistry concerns and limit this impact to the short-term. Isolated spill accidents, should they occur, could result in minor soil contamination from oils, solvents, etc. Such spills will normally result in soils deemed unsuitable for reclamation. Soils so affected could be buried to effectively reduce the effects of this impact or otherwise be disposed of in accordance with state and federal waste regulations. The volume of soil subject to spills would be limited, however, given the plan to salvage suitable soils prior to operational disturbances and the proposed implementation of a Spill Prevention Plan. Therefore, no impact to revegetation potential is anticipated.

Subsurface materials upon which salvaged soils will potentially be replaced consist of endemic subsoils, two general types of waste rock, and tailings. Baseline data indicate that endemic subsoils contain no chemical constituents that would degrade soils applied for revegetation purposes, given that these subsoils naturally underlie the project area (Houlton and Noel 1995, Revised). Unoxidized (or "dump") waste rock is typically acidic with mean paste and NAG pH values of 5.5 and 3.3, respectively. The ABA of this material, computed by subtracting the acid potential from the neutralizing potential, averages approximately -48 tons of $CaCO_3$ per 1,000 tons of material, indicating a waste rock with a high potential to generate acid through time. Oxide (or "oxidized") waste rock, which will be used to "cap" unoxidized waste rock during reclamation activities, exhibits a higher average paste pH value of 5.8 and higher NAG pH values ranging, on average, from 5.0 to 5.7. The ABA of these materials exhibit average ranges from -2.7 to -9.5 tons of $CaCO_3$ per 1,000 tons of material, indicating a waste rock type which will be notably less acid-producing and more amenable to vegetation establishment than unoxidized waste rock. Tailings, which have an initial high pH averaging 8.4 due to ore processing activities, are an acid-producing material on the order of unoxidized waste rock, with a NAG pH of 2.4. The average ABA of tailings is -77 tons of $CaCO_3$ per 1,000 tons of material (Schafer and Associates 1995a). Soils placed over the acid-producing unoxidized waste rock and tailings materials could be subject to some level of degradation at the soil/waste material interface and to some depth above this zone due to capillary rise (MDSL and BLM 1990). The extent to which this will occur is likely to be limited, given the revegetation techniques proposed by GSM, as discussed below.

Isolated steam venting from settling cracks in waste rock dump test plots is occurring at a number of locations. Venting could cause a modification of soil chemical conditions leading to a change in the vegetation communities over time. Venting locations will need to be monitored by agency reclamation specialists to document the effects of venting on soil chemistry and vegetation of the surrounding area. Any significant changes in vegetation over time will determine the need for soil testing and analysis to determine the effect venting has had on soil chemistry. Mitigation Measure S-1, in Section IV.P. Potential Mitigation and Monitoring, has been developed to address this issue.

Wind erosion can be expected on exposed soils, although the potential for wind erosion is not considered to be of primary concern at the project site, when compared with the potential for water erosion (MDSL and BLM 1990). With regard to the impacts of wind erosion, the time between initial soil exposure during salvage operations and subsequent activities such as waste rock deposition would be comparatively short, given the operations scheduling. In addition, temporary soil stockpiles will be stabilized following stockpiling operations. Further, all trafficked disturbances such as haul and access roads will be covered with a surfacing material and/or regularly treated for dust suppression purposes to reduce the potential impacts of wind erosion. Therefore, the impact to soils during salvage operations should be limited and not reduce revegetation potential.

All resoiled areas will be subject to wind erosion above the level naturally occurring until revegetation is successful. Prompt application of the proposed revegetation techniques and the blending of soil horizons high in coarse fragment content with more erodible soil textures should help to reduce this impact in terms of both time and degree. GSM's commitment to concurrent reclamation also will help to reduce the impacts of wind erosion.

The potential for water erosion on slopes to be revegetated is specifically addressed below in conjunction with the results of waste rock dump test plot studies. Water erosion on the tailings facility and plant site facility surfaces is not expected to occur to any notable degree due to the revegetation methods proposed, characteristics of the soils to be applied, and the nearly level slopes of these facilities.

IV.C.1.a Reclamation (Revegetation) Considerations

General Considerations

Facilities disturbed under the No Action Alternative, will be either wholly or partially revegetated. Those that will be completely revegetated include the waste rock dumps, tailings facilities, plant area, borrow areas, permanent water treatment plant, and buffer zone disturbances. The majority of the revegetation/reclamation techniques to be employed under this alternative parallel those proposed under the other alternatives being considered with one exception. The tailings facility under this alternative is proposed to be reclaimed using a 48-inch depth cap which includes a lower base 18-inch clay barrier as opposed to a 48-inch cap composed of equal depths of soil and waste rock under the other six alternatives. The virtues of each of these capping scenarios are discussed under Section IV.C.2 Proposed Action Alternative. Revegetation activities in the pit will include capping 53 acres of major benches with 24 inches of oxidized rock overlain with 24 inches of soil. Approximately 177 acres of inaccessible and highwall areas in the pit will not be revegetated. In addition, 31 acres of road disturbance will not be revegetated.

The techniques, materials, and systems proposed by GSM to revegetate project area disturbances are appropriate for use on-site. They either have a proven history of successful application in past revegetation projects in the West or have been developed on-site in response to site-specific needs and conditions, and baseline studies. Research conducted at the mine site concludes that the capping systems for the tailings and waste rock disturbances offer a successful method of isolating acid-producing wastes from reapplied soil materials which, in turn, fosters an acceptable revegetation potential. The high $CaCO_3$ content of soils present in the eastern, northeastern, and southern portions of the project area also will aid in promoting revegetation success. The seeding and fertilizing methods and the materials proposed for use have all been successfully applied on-site during past revegetation test plot programs. Soil management activities, as well as other aspects of GSM's reclamation plan, have been based, in part, on the data made available as a result of the soil surveys conducted on site. Continued successful application should be achievable, assuming continuing attention to detail, particularly in terms of waste rock dump slope revegetation. Mulching, which was included as a part of the successful test plot program, is not formally proposed as a part of the revegetation plan prepared for this mining operation. The effect of this decision is discussed below under the heading "2:1 Versus 3:1 Slope Angle Revegetation Success Potentials." The vegetation species proposed for planting are adapted to the range of climatic and edaphic conditions which are endemic to the project site. The planting of tree seedlings grown from seeds collected locally adds to the potential diversity of the reclaimed vegetation communities. Modification of the mixtures currently proposed may be advisable as the results of the test plot programs continue to be evaluated.

A total of 2,336 acres are proposed to be disturbed under the No Action Alternative (see Table IV-8). This alternative would affect from 407 to 742 acres less total disturbance than the other alternatives being considered. Of the total disturbance, 1,148 acres require either a waste rock dump- or tailings impoundment-type cap of 48 (+) inches. Operations under the No Action Alternative, therefore, would result in 308 to 545 acres less of potentially acid-producing waste rock/tailings material than any other alternative. The total cap rock volume required is 3,851,300 cubic yards (see Table IV-9). The total volume available is 3,500,500 cubic yards, leaving a shortfall of 350,800 cubic yards, which must be obtained from other areas. Mitigation Measure S-2, in Section IV.P. Potential Mitigation and Monitoring, has been developed to address this situation.

A total of 1,893 acres will require some form of soil cover, including 745 acres of non-acid generating disturbances requiring a six-inch soil cover system, and 1,148 acres requiring both cap rock and soil cover systems. Approximately 4,154,700 cubic yards of suitable soil material will be required to resoil disturbed areas under this alternative (see Table IV-10). A maximum of approximately 3,831,800 cubic yards of suitable soil is available for this purpose, including 3,069,800 cubic yards currently stored in existing soil stockpiles and 762,000 cubic yards overlying the acreage scheduled to be disturbed under this alternative. A shortage of 322,900 cubic yards will occur under this alternative, unless made up by additional salvage from other areas. This shortage amounts to 92 percent of the total soil volume needed for reclamation. This is within the margin of error of the methods used by the agencies to calculate soil volume needed for reclamation, taking into account errors in volume calculations, soil variability, etc. The 8 percent needed can be recovered from identified salvageable soil resources in the proposed borrow areas and buffer disturbances if a shortfall in volume does occur. Mitigation Measure S-3, in Section IV.P. Potential Mitigation and Monitoring, has been developed to address a potential shortage in soil volume.

A total of 339 acres of 2:1 slopes and 118 acres of 3:1 slopes will be created as a result of this alternative (see Table IV-11). This is the lowest slope acreage total of any alternative. To date, approximately 26 acres of test plot area have been reclaimed to a 2:1 slope angle within the boundaries of the project area. Of this total, approximately 18 acres have been covered with 19 inches of soil, and 8 acres have been covered with 24 inches of soil. The agencies must decide, as a part of the permitting process, whether this test plot acreage will need to be reduced to a 3:1 slope and revegetated a second time to meet current and/or proposed reclamation/revegetation goals.

2:1 Versus 3:1 Slope Angle Revegetation Success Potentials

GSM proposes to reclaim waste rock dump slopes at both 2:1 and 3:1 slope angles, with the majority consisting of 2:1 slopes. GSM emphasizes the 2:1 slope angle in the company's reclamation plan for a variety of reasons. Runoff from this slope angle is greater than that from a 3:1 slope, thereby reducing the precipitation that would infiltrate the waste rock dump facility which, in turn, reduces the potential volume of effluent from the unoxidized waste rock stored in each dump. A concomitant reduction in potential ARD is assumed. In addition, the overall area disturbed by a 2:1 slope is less than that required by a 3:1 slope, resulting in less acreage to be disturbed, bonded, resoiled, and reclaimed. During previous permitting activities, the MDEQ required that GSM bond the waste rock dump disturbances as if they were to be reclaimed at consistent 3:1 slope angles and conduct studies or provide information to determine whether the dumps could indeed be successfully reclaimed at 2:1 slopes. MDEQ's preference for 3:1 slopes was based on the widely held premise that lesser slopes exhibit higher revegetation potentials due to lower potential erosion rates, enhanced equipment access/efficiency/safety factors, and greater precipitation infiltration leading to a more plant-amenable soil moisture regime. Erosion potential calculations also were completed by the MDEQ using the Universal Soil Loss Equation (USLE). The results of this modeling analysis indicated that 3:1 slope angles are less susceptible to erosion than 2:1 slopes, given assumed site-specific conditions (MDSL and BLM 1990).

GSM continues to reclaim waste rock dumps slopes under the existing reclamation plan and has entered into an extensive test plot program (Schafer and Associates 1995a) to determine the feasibility of successfully reclaiming 2:1 slopes, as well as to reduce the potential for waste rock dump effluent production. Demonstration plots were constructed, using appropriate techniques, on the West Waste Rock Dump in 1992 and on the East Waste Rock Dump (High Grade Waste Rock Dump) in 1991. With respect to test objectives, West Waste Rock Dump studies were designed to provide information related to 2:1 slope waste rock dump hydrology in light of applied revegetation techniques, while the East Waste Rock Dump study was constructed to evaluate grade control factors, capping techniques, and revegetation performance on a variety of slope angles. The capping techniques and waste rock sampling procedures, as well as the oxide cap characteristic criteria proposed as a part of the reclamation plan for this alternative (see Section II.B.1.b, Existing Reclamation Plan), were developed as a result of these studies.

The results of both studies are central to assessing the feasibility of successfully reclaiming 2:1 waste rock dump slopes. The feasibility of success may be best assessed in light of both the incidence of soil erosion and the establishment of vegetation communities with respect to the climatic conditions under which the studies were conducted. Through 1994, sedimentation rates for both 2:1 and 3:1 test plots on the West Waste Rock Dump were statistically comparable to natural rates from the 2:1 sloping Reference Area No. 3. Similarly, vegetation cover was measured on 2:1 slopes and found to have exceeded that of Reference Area No. 3 and to have surpassed the vegetation success criteria established for this project. The results of data analyses for the East Waste Rock Dump study are similar through 1994. Erosion rates between 2:1 and 3:1 test plots and Reference Area No. 1 were statistically comparable. Vegetation cover values for both 2:1 and 3:1 test plots exceeded those of Reference Area No. 1 for the 1992 and 1994 sampling dates.

The Revised Universal Soil Loss Equation (RUSLE) model was used as an adjunct analytical tool in combination with site specific data to assess the potential for erosion on 2:1 versus 3:1 slopes for this EIS. The parameters and data used in the model assumed that previously tested techniques, methods, and materials (including mulching) would be used during formal revegetation activities. The model was run for both slope angles using soil salvage information prepared for the West Waste Rock Dump. Two time frames were assumed: 1 year following revegetation to determine potential erosion rates following the first year of plant establishment and 5 years following revegetation to determine the potential for erosion from an established vegetation community. Two soil salvage scenarios also were evaluated. The first assumed that all available soil material suitable for salvage was stockpiled and spread prior to revegetation. This material contained a weighted average of 50 percent coarse fragments by volume. The second scenario assumed that only surface soils having less than 20 percent coarse fragments by volume were salvaged and reapplied during revegetation activities. The weighted average coarse fragment content by volume of this material was 7 percent. The MDEQ has set a value of 2 tons per acre as the maximum acceptable soil loss allowable. Appendix M depicts the values for the parameters used for all scenarios to complete this analysis.

Application of the high coarse fragment content soil material to both slope angles results in acceptable potential erosion rates for both time frames. Potential erosion rates are 1.8 and 1.2 tons per acre per year for the 1- and 5-year time frames, respectively, on 2:1 slopes. The values for 3:1 slopes are 1.1 and 0.8 tons per acre per year for the same time frames. Application of low coarse fragment content soils results in a notably different situation. The potential erosion rates for 2:1 slopes under this soil replacement scenario are 7.2 and 9.8 tons per acre per year for the 1- and 5-year time frames, respectively. For 3:1 slopes, these values are 4.8 an 5.0 tons per acre per year. This analysis underscores the value of the application of high coarse fragment content soils as armoring to reduce the potential for erosion, particularly on 2:1 slopes.

Weighted average calculations for soil coarse fragment content were completed for a major portion of the soils to be salvaged at the buttress, West Waste Rock Dump (3:1 Alternative only), and East Waste Rock Dump. Not all soils to be salvaged from and reapplied to these disturbances are accounted for in these calculations. A significant volume of soil currently exists in stockpiles, the coarse fragment content of which cannot be calculated given existing soils/operational information. Coarse fragment content information also is limited for a small number of soil map units mapped by Westech (GSM 1995b). No calculations were made for the soils overlying the tailings facility, since the potential for water erosion is not an issue with regard to this nearly level facility component.

Soil volumes considered as "suitable for salvage" by GSM, which corresponds to the volume GSM will salvage, vary somewhat in their weighted average coarse fragment content based on those soils for which calculations can be made. Weighted averages for the buttress dump, West Waste Rock Dump, and East Waste Rock Dump areas are 38, 35, and 23 percent, respectively. If these values can be assumed to be generally representative of all soils available for replacement, there should be a sufficient coarse fragment content present to achieve the revegetation goals set for 3:1 slope angles. This content may be somewhat less than that necessary for adequately reducing erosion of 2:1 slopes during the plant establishment period based on the RUSLE computations noted above. However, the 37 and 35 percent present, if indicative of the soils available, is in the range of that noted by Richardson (1995) as being present on the Golden Sunlight Mine 2:1 slopes on-site where successful revegetation has taken place. It can, therefore, be proposed that adequate soil coarse fragment contents are present on the soils on the western side of the project area, given a very broad range of assumptions. Attention will need to be paid to the quality of the soils to be replaced on proposed 2:1 slopes under any alternative to ensure that sufficient coarse fragments are present to serve as a partial rock armoring. Mitigation Measure S-4, in Section IV.P. Potential Mitigation and Monitoring, has been developed to address this issue. Where the coarse fragment content proves to be insufficient, additional erosion control measures would need to be instituted to provide the proper level of slope protection.

Schafer and Associates (1995a) indicate that, using the steep slope reclamation technique system (capping, contour benching, dozer gouging, mulching, intensive material sampling, etc.) developed for this project, 2:1 slopes can be successfully reclaimed, as compared to adjacent undisturbed steep slope conditions. There does not appear to be a compelling advantage to requiring 3:1 dump slopes at the Golden Sunlight Mine, with the possible exceptions of equipment access/efficiency/safety factors related to site maintenance. The oxide waste rock material sampling and analysis methodology developed by GSM personnel and company consultants appears to offer a reliable means of testing the success of capping efforts, assuming that the program of laboratory conformation analyses is continued and the results of such testing are used to guide revegetation activities. However, the positive and negative aspects of the climatic conditions prevailing during the term of the waste rock reclamation studies also must be considered in this assessment with respect to how such conditions may have affected the study results. While annual precipitation totals for 1991 and 1992 were near the long-term average of 13.3 inches, approximately 20 inches fell on-site in 1993. In 1994, approximately 15.3 inches were incident to the site (Schafer and Associates 1995a). These greater-than-normal annual precipitation rates may serve as a type of natural "worst-case scenario" when considering the effect slope angle has on both infiltration/ARD effluent production and soil erosion. Under these enhanced climatic

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conditions, the soil/oxide rock cover system selected for covering the waste rock dump slopes (both 2:1 and 3:1) functioned successfully in terms of limiting infiltration into the waste rock dump. Also, soil erosion under these greater-than-normal precipitation conditions was limited to an acceptable level regardless of slope, although it was found that erosive power is greater on 2:1 as compared to 3:1 slopes as discussed above. Conversely, the enhanced precipitation rates bring into question the potential for revegetation success of waste rock slopes under both average or below average annual precipitation conditions. Although unsupported by on-site empirical data, the enhanced 1993 and 1994 precipitation rates are assumed to have benefited revegetation efforts on both 2:1 and 3:1 slope angle test plots in terms of the vegetation cover produced, which will not likely be typical under average or below average annual precipitation conditions. It was observed that vegetation cover produced under these amenable precipitation conditions was in excess of that produced on the reference areas during the same time period regardless of slope angle (Schafer and Associates 1995a). If the excess in test plot vegetation production over that found on reference areas can be attributed to enhanced rainfall conditions in 1993 and 1994, then it seems reasonable to assume that under normal precipitation conditions both 2:1 and 3:1 slopes can be successfully revegetated.

The question of revegetation cover production under below average precipitation conditions remains. The 2:1 slope angle was shown to have experienced more precipitation runoff and less infiltration than the 3:1 slope angle. The fact that this occurred during the test plot studies is documented by Schafer and Associates (1995a) in noting that "....2H:1V slopes show less infiltration than 3H:1V slopes." Increased runoff will limit to some degree the amount of precipitation that will enter the soil and be available to plants for establishment and growth on 2:1, as compared to 3:1 slope angles. The effect that this factor would have during periods of drought on revegetation success cannot accurately be predicted. It seems reasonable to assume, however, that the differences in runoff between the slope angles will not lead to a reclamation failure when considering the overall revegetation success experienced on-site, the vegetation cover capable of being produced on similar adjacent undisturbed slopes through time, and the fact that a drought will affect both 2:1 and 3:1 slopes simultaneously. It therefore seems appropriate to conclude that, while vegetation cover will be somewhat higher on 3:1 slopes due to decreased runoff, 2:1 slopes can be successfully reclaimed, as compared to reference area conditions under limited periods of below average annual precipitation using proven revegetation techniques.

In summary, it may be concluded that either 2:1, 3:1, or any combination of these slope angles can be successfully reclaimed given the use of an applicable sequence of proven reclamation techniques and attention to detail. Techniques of proven applicability and value, as shown in part by site-specific research, include resoiling with soils containing high (up to 50 percent by volume) rock fragment contents, slope length reduction, surface pitting, rock armoring, seeding with appropriate plant species, and mulching. GSM, however, does not propose to include mulching or soils containing high rock fragment contents as an integral part of the post-operational revegetation sequence. Instead, the company proposes that certain seedbed manipulation techniques be used in place of mulching, and that soils containing rock fragment contents of 20 percent be used to limit erosion rather than soils containing high rock fragment contents (GSM 1995b). While such techniques may have value, it is mulching in combination with soils containing high (up to 50 percent by volume) rock fragment contents which has been proven to be successful as a part of the established revegetation sequence under site-specific conditions. In the absence of these techniques, it cannot be concluded, particularly on 2:1 slopes, that revegetation will attain the level of success shown on the test plots. At this point it must be concluded that steep slope revegetation success at the Golden Sunlight Mine site is questionable and may not achieve the goals set for this project. Mitigation Measures S-4 and S-5, in Section IV.P. Potential

Mitigation and Monitoring, have been developed to address this situation.

IV.C.2 Proposed Action Alternative

The physical, microbial, and chemical impacts to soils discussed in Section IV.C.1, No Action Alternative, are the same for this alternative in both kind and degree. Although soils may be stockpiled for a longer time period, the impacts to soils as a result of this activity should be the same as for the No Action Alternative.

IV.C.2.a Reclamation (Revegetation) Considerations

General Considerations

The techniques, materials, and systems proposed by GSM to revegetate project area disturbances are appropriate for use at the mine. All other general considerations for this alternative would be the same as discussed in Section IV.C.1, No Action Alternative, except as noted below. The previous analyses related to slope revegetation potentials also are applicable to this alternative.

All facilities that have been disturbed to date, or that would be disturbed in the future would be either wholly or partially revegetated. Those that would be completely revegetated include the waste rock dumps, tailings facilities, plant area, borrow areas, permanent water treatment plant, and buffer zone disturbances. Revegetation activities in the pit would include vegetation planting on the oxidized pit benches that exhibit a potential for revegetation success, as noted for the No Action Alternative. Approximately 19 acres of major benches in the pit would be capped with 24 inches of oxidized rock overlain with 24 inches of soil and revegetated. Approximately 235 acres of inaccessible and highwall areas in the pit and 24 acres of road disturbance would not be revegetated.

A total of 2,884 acres are proposed to be disturbed under this alternative. This is the same acreage as is proposed to be disturbed under the No Pit Pond and Partial Backfill Alternatives. It is also comparable to the proposed disturbance acreage of the other alternatives except the No Action Alternative, which is less (2,336 acres). Of the total disturbance, 1,539 acres would require either a waste rock dump- or a tailings impoundment-type cap. As noted on Table IV-8, this acreage is similar to that of the majority of the alternatives, except the No Action Alternative (1,148 acres), 3:1 Slope Alternative (1,684 acres), and the Partial Backfill Alternative (1,650 acres). Sufficient cap rock material exists for this purpose under this alternative. The total cap rock volume required would be 5,140,100 cubic yards (Table IV-9). The total volume available would be 6,195,700 cubic yards, including 3,454,800 cubic yards currently stored in existing cap rock stockpiles and 2,740,800 available from the areas proposed to be disturbed. There would be a surplus of approximately 1,055,500 cubic yards of cap rock.

A total of 2,506 acres would require some form of soil cover, including 967 acres requiring a six-inch soil cover system, and 1,539 acres requiring both cap rock and soil cover systems. GSM has calculated that approximately 5,622,300 cubic yards of suitable soil material would be required to resoil disturbed facilities (Table IV-10). Approximately 6,375,200 cubic yards of suitable soil would be available for this purpose, including 3,069,800 cubic yards currently stored in existing soil stockpiles and 3,305,500 cubic yards overlying the acreage proposed to be disturbed under this alternative. A surplus of 753,000 cubic yards (12 percent) of soil would be available for reapplication.

A total of 341 acres of 2:1 slopes and 258 acres of 3:1 slopes would be created as a result of this alternative (see Table IV-11). This is an additional 2 acres of 2:1 slopes and 140 acres of 3:1 slopes over the No Action Alternative.

Tailings Chemistry Impacts to Revegetation Potential

With EA Stipulations 12, 13, and 18 (MDSL and BLM 1990), the agencies addressed, in part, the potential impacts to the soil resource as a result of tailings material quality. Direct revegetation of tailings is not considered feasible. Tailings are typically sand- to silt- sized material that have an initial high pH but also a high potential to generate acid over time, as noted above. Therefore, the concern with respect to tailings revegetation is that the acid generated by oxidation of the tailings could migrate into overlying reapplied soil, thereby degrading the soil and leading to a revegetation failure. The stipulations noted above required that GSM construct and monitor tailings test plots to determine suitable means of avoiding this problem. Test plots were constructed in 1982 for testing three earthen material systems for capping and revegetating impounded tailings. Monitoring occurred through the latter part of 1988 with testing that included a simulated 10-year storm (rainfall) event. Dollhopf et al. (1988) determined that all methods tested were similar, relative to the parameters tested, and that any of the cover systems evaluated would be effective in terms of decommissioning the tailings impoundment.

Based on this information, GSM proposes to cover the tailings material with a combination of soil borrow material overlain with salvaged soil material since this system (of those tested) is considered to be more practical to construct and more cost "feasible." It also was noted that a cover-soil/borrow material cover system may exhibit better long-term stability than the other systems tested, which included a clay cap barrier (Dollhopf et al. 1988). The cover-soil/borrow material cover system successfully tested consisted, on average, of approximately 88 inches of material, of which 37 and 50 inches were cover-soil and borrow soil material, respectively. GSM proposes to use 48 inches of material as a cap, which would consist of borrow material and cover-soil at depths of 24 inches each. GSM believes that the proposed lesser depth would perform adequately, and reclamation under this system would be successful.

Based on EIS analysis, it would appear that this assessment is correct and that the proposed cover depth is adequate to support revegetation. The cover system placed over potentially toxic tailings should achieve three objectives: 1) prevent tailings moisture recharge by incident precipitation events, 2) prevent the degradation of overlying soil materials by chemical constituents (sulfide oxidation products) migrating upward from the underlying tailings, and 3) provide a soil depth of sufficient thickness to support the planned vegetation community. Although the cover-soil/borrow material depth proposed would be less than that tested, it should be sufficient to prevent, or reduce to acceptable levels, recharge of the underlying tailings from precipitation events based on modeling completed by Schafer and Associates (1989b) for a 48-inch cap depth. Dollhopf et al. (1988) inferred that, based on the tailings test plot data, migration of contaminants from the tailings into the overlying cover-soil should not take place. Borth (1988) reported, in an overview study, that capillary rise in spoil or tailings cover systems is typically limited and ranged from less than 2 to over 8 inches under a variety of soil and climatic conditions. Although not specific to the Golden Sunlight Mine site, this information is instructive. The potential for capillary rise, or upward migration, of acid products was summarily addressed in the waste rock dump studies completed on-site (Schafer and Associates 1989a). Where assessments could be made, it appeared that upward migration was limited to a maximum 4-inch depth. Nevertheless, Mitigation Measure S-6, in Section IV.P. Potential Mitigation and Monitoring, has been developed to address the uncertainty associated with predicting the extent of potential upward migration of acid products in waste rock and tailings impoundment cover materials. Additional protection from capillary rise in the tailings cover impacting revegetation success is provided by the soil itself. The soil materials in the area of the tailings facilities that would be available for use as capping material, as noted previously, exhibit a moderate to high pH-buffering capacity in the form of a moderate to high neutralization potential. The proposed tailings capping, therefore, meets the first two capping objectives.

Assuming capillary rise of sulfide oxidation products would occur to a maximum "worst case" of 8 inches, a base of 40 inches of soil would remain to support the revegetation plant community under the proposed reclamation plan. Given that the majority of plant roots can typically be found in the top 20 inches of soil, it is believed that twice this amount of soil would serve to support the planned revegetation community under worst-case capillary rise conditions at the tailings facility. The detailed soil survey completed on-site further supports the adequacy of the proposed 40-inch cap depth. The majority of the plant roots observed in the soil profiles of the dominant soils surrounding the tailings site occurred in the upper 24 to 40 inches of the soil profile. (Houlton and Noel 1995, Revised).

IV.C.3 Return Diversion Alternative

The physical, microbial, and chemical impacts to soils discussed in Section IV.C.1, No Action Alternative, would be the same for this alternative in both kind and degree.

IV.C.3.a Reclamation (Revegetation) Considerations

As discussed for the Proposed Action, the techniques, materials, and systems proposed by GSM to revegetate project area disturbances are appropriate for use on-site. All other general considerations for this alternative would be the same as discussed in Section IV.C.1, No Action Alternative. The previous analyses related to tailings chemistry and slope revegetation potentials also are applicable to this alternative.

The acreage proposed to be disturbed under this alternative would be the same as for the Proposed Action, with and additional 2.5 acres disturbed for the diversion of Sheep Rock Creek. Cap rock requirements would be the same as for the Proposed Action. Soil requirements would include an additional 2,000 cubic yards, resulting in a slightly smaller surplus of soil (751,000 cubic yards) than under the Proposed Action. The acreage of 2:1 and 3:1 slopes to be created would be the same as for the Proposed Action, and the areas revegetated would be the same plus the additional 2.5 acres of the diversion area resoiled and revegetated.

IV.C.4 Divided Dump Alternative

The physical, microbial, and chemical impacts to soils discussed in Section IV.C.1, No Action Alternative, would be the same for this alternative in both kind and degree.

IV.C.4.a Reclamation (Revegetation) Considerations

As discussed for the Proposed Action, the techniques, materials, and systems proposed by GSM to revegetate project area disturbances are appropriate for use on-site. All other general considerations for this alternative would be the same as discussed in Section IV.C.1, No Action Alternative. The previous analyses related to tailings chemistry and slope revegetation potentials also are applicable to this alternative.

The facilities proposed for revegetation, and the revegetation techniques to be employed to achieve reclamation objectives would be the same as discussed for the Proposed Action Alternative in Section IV.C.2. Two different waste rock dump scenarios have been described in order to analyze the potential impacts under this alternative. Under the minimum disturbance scenario, Area C2 would be utilized for waste rock disposal. Under the maximum disturbance scenario, the land bridge, and Areas A and B2 would be utilized for waste rock disposal.

Under the minimum scenario, a total of 2,743 acres would be disturbed. Under the maximum scenario, a total of 2,936 acres would be disturbed. These acreages are comparable to those of the other alternatives, except the No Action Alternative, which has a smaller disturbance area (2,336 acres), and the 3:1 Slope Alternative, which has greater disturbance area (3,078 acres). Areas requiring cap rock total 1,456 acres for the minimum scenario and 1,580 acres for the maximum scenario. These totals are generally comparable with the majority of the alternatives being considered, with the exception of the No Action Alternative, which has a smaller area requiring cap rock (1,148 acres). Under the minimum scenario, 4,885,200 cubic yards of cap rock would be required. Under the maximum scenario, 5,346,500 cubic yards of cap rock would be required. Sufficient capping material would be available under both scenarios. Under the minimum scenario, there would be a surplus of 1,300,400 cubic yards of cap rock. Under the maximum scenario, there would be a surplus of 849,200 cubic yards.

Soil cover would be required over 2,280 acres under the maximum scenario, including 824 acres requiring a six-inch soil cover system and 1,456 acres requiring both cap rock and soil cover. Soil cover would be required over 2,431 acres under the maximum scenario, including 841 acres requiring a six-inch soil cover system and 1,590 acres requiring both cap rock and soil cover. These totals are generally lower than the other alternatives (see Table IV-8). Approximately 5,175,400 cubic yards of soil would be required under the minimum scenario, and 5,727,500 cubic yards under the maximum scenario. The maximum scenario would result in a surplus of 229,500 cubic yards of soil (4 percent). The minimum scenario would result in a shortfall of 411,000 cubic yards (9 percent). This 9 percent deficit could be made up as described under the No Action Alternative, and the impact mitigated. Mitigation Measure S-3, in Section IV.P, Potential Mitigation and Monitoring, has been developed to address this deficit.

Approximately 258 acres of 3:1 slopes and 442 acres of 2:1 slopes would be created under the minimum scenario. Approximately 186 acres of 3:1 slopes and 489 acres of 2:1 slopes would be created under the maximum scenario. These totals for 2:1 sloped areas are among the highest of all of the alternatives being considered (see Table IV-11).

IV.C.5 2:1 Slope Alternative

The physical, microbial, and chemical impacts to soils discussed in Section IV.C.1, No Action Alternative, would be the same for this alternative in both kind and degree.

IV.C.5.a Reclamation (Revegetation) Considerations

As discussed for the Proposed Action, the techniques, materials, and systems proposed by GSM to revegetate project area disturbances are appropriate for use on-site. All other general considerations for this alternative would be the same as discussed in Section IV.C.1, No Action Alternative. The previous analyses related to tailings chemistry and slope revegetation potentials also are applicable to this alternative.

The facilities proposed for revegetation, and the revegetation techniques to be employed to achieve reclamation objectives would be the same as discussed for the Proposed Action Alternative in Section IV.C.2.

A total of 3,078 acres are proposed to be disturbed under this alternative. This is the largest acreage of any of the alternatives being considered, due to the area required to construct 3:1 versus 2:1 waste rock dump slopes. In terms of capping requirements, this alternative is among the highest of those alternatives being considered, again, due to the area needed to construct waste rock dump 3:1 slopes. Of the total acreage, 1,684 acres would require either a waste rock dump- or tailings impoundment-type cap. The total cap rock volume required would be 5,514,200 cubic yards, resulting in a surplus of 681,500 cubic yards from the amount available.

A total of 2,620 acres of disturbance would require some form of soil cover system for revegetation, including 956 acres of non-acid generating surfaces requiring a 6-inch soil cover, and 1,684 acres requiring both cap rock and soil cover systems. Approximately 5,924,500 cubic yards of suitable soil material would be required to resoil disturbed facilities under this alternative. The total available would be 6,531,500 cubic yards, including 3,069,800 cubic yards currently stored in existing soil stockpiles, and approximately

3,461,700 cubic yards that would be available for salvage from the acreage that would be disturbed. A surplus of 607,000 cubic yards (9 percent) over the volume needed for reapplication would be available.

No 2:1 slopes would be constructed under this alternative. Approximately 824 acres of 3:1 slopes would be created. This is approximately 225 acres more slope disturbance than would be created under the Proposed Action, and 367 acres more than the No Action. GSM has calculated that an additional 302,200 cubic yards of soil would be required to be salvaged and reapplied to the increased disturbance associated with the West and East Waste Rock Dumps. Soil to be salvaged would come from the area over which the waste rock dumps would be constructed. Additional soil salvage in the area of the West Waste Rock Dump would likely increase the overall coarse fragment content of the salvaged/stockpiled soil material to a slight degree.

IV.C.6 No Pit Pond Alternative

The physical, microbial, and chemical impacts to soils discussed in Section IV.C.1, No Action Alternative, would be the same for this alternative in both kind and degree.

IV.C.6.a Reclamation (Revegetation) Considerations

The techniques, materials, and systems proposed by GSM to revegetate project area disturbances are appropriate for use on-site. All other general considerations for this alternative would be the same as discussed in Section IV.C.1, No Action Alternative. The previous analyses related to tailings chemistry and slope revegetation potentials are also applicable to this alternative.

The effects to soils, in terms of quantity and quality would be identical to those discussed in Section IV.C.2, Proposed Action Alternative. The facilities proposed for revegetation, the revegetation techniques to be employed to achieve reclamation objectives, and the acreages of 2:1 and 3:1 slopes would be the same as discussed for the Proposed Action Alternative in Section IV.C.2.

The disturbance area for this alternative would be the same as for the Proposed Action, but there would be an additional 7 acres of pit benches capped, resoiled, and revegetated, associated with partial backfilling activities in the pit. Consequently, the cap rock and soil requirements would be 22,000 cubic yards greater than under the Proposed Action. Approximately 5,162,100 cubic yards of cap rock would be required, and 5,644,300 cubic yards of suitable soil material would be required to cover disturbed areas. There would be a surplus of 731,000 cubic yards (11 percent) of salvageable soil under this alternative.

IV.C.7 Partial Backfill Alternative

The physical, microbial, and chemical impacts to soils discussed in Section IV.C.1, No Action Alternative, would be the same for this alternative in both kind and degree.

IV.C.7.a Reclamation (Revegetation) Considerations

The techniques, materials, and systems proposed by GSM to revegetate project area disturbances are appropriate for use on-site. All other general considerations for this alternative would be the same as discussed in Section IV.C.1, No Action Alternative. The previous analyses related to tailings chemistry and slope revegetation potentials also are applicable to this alternative.

The effects to soils, in terms of quantity and quality, are similar overall to those discussed in Section IV.C.2, Proposed Action Alternative. However, an additional 829,400 cubic yards of soil would be required for revegetating the backfilled pit over and above that required for the Proposed Action. The increase in soil volume required would be compensated for, in part, by a reduction in the soil volume needed to resoil approximately 82 acres of the East Waste Rock Dump from which waste rock would be off-loaded and placed in the pit. The depth necessary for resoiling this acreage would be reduced from 24 inches (264,600 cubic yards) to 6 inches (66,200 cubic yards), since no waste rock would be present on this acreage and buffer zone resoiling depths would be required. Facilities proposed for revegetation and the revegetation techniques to be employed to achieve reclamation objectives, would be essentially the same as discussed for the Proposed Action Alternative in Section IV.C.2. However, all areas of the pit would be revegetated, leaving only 24 acres of roaded areas not revegetated.

A total of 2,964 acres would be disturbed under this alternative. This is the same as for the Proposed Action and No Pit Pond Alternatives, and comparable to the other alternatives except the No Action Alternative, which has a smaller disturbance area (2,336 acres). However, capping material requirements are the highest of any of the alternatives, due to backfilling activities in the pit. A total of 1,693 acres of disturbance would require waste rock dump- or impoundment-type caps. The total volume of cap rock required would be 5,692,200 cubic yards, resulting in a surplus of 503,400 cubic yards.

A total of 2,742 acres of disturbance would require some form of soil cover system for revegetation, including 1,049 acres requiring a 6-inch soil cover, and 1,693 acres requiring both cap rock and soil cover systems. This is also the highest acreage figure for soil cover of any of the alternatives. Approximately 6,245,100 cubic yards of suitable soil material would be required to resoil disturbed facilities. Approximately 6,375,300 cubic yards of suitable soil would be available for this purpose. A surplus of 130,200 cubic yards (2 percent) over that needed for reapplication would be available under this alternaive.

A total of 258 acres of 3:1 slopes and 494 acres of 2:1 slopes would be created under this alternative. The area of 3:1 slopes would be the same as for the Proposed Action. The area of 2:1 slopes would be the largest of any of the alternatives being considered.

IV.D VEGETATION AND WETLANDS

Impacts to vegetation include the disturbance, removal, or burying of vegetation resulting from mine expansion activities. These activities include waste rock placement in the waste rock dump and buttress expansion areas, removal of borrow material from the future borrow area, and placement of tailings material in the tailings impoundment area. Impacts to vegetation would occur gradually throughout the proposed mine life. Mine expansion would predominantly occur in undisturbed areas. However, mine expansion also would occur on land that has been previously disturbed by past mining activities. The impact analysis for the various alternatives was based on the acreage and types of vegetation located on previously undisturbed land since these areas include a prevalence of native species. Previously disturbed land was not included in the impact analysis since these areas are typically barren or support only small populations of weedy species.

The removal of vegetation by mining activities also would reduce species diversity. As described in Chapter III, Section III.D, Vegetation and Wetlands, the floristic diversity of the previously undisturbed plant communities present within the project area ranges from 35 to 99 species per community. Pastureland areas, which have been plowed and planted to improve dryland pasture species for increased spring grazing use, have an even lower floristic diversity (27 species). A total of 355 species (73 graminoids, 248 forbs, and 34 woody plants) were observed during vegetation surveys conducted within the project vicinity (Scow 1995). The reclamation seed mixes to be used on the waste rock dumps, tailings impoundments, and other disturbance areas range from 10 to 16 species of which 5 are non-native species. After mine operation and completion of reclamation, reclaimed plant communities would support approximately 10 to 16 species which would be approximately 25 to 83 fewer species than present in undisturbed plant communities. Species diversity would slowly increase ovr a long period of time.

IV.D.1 No Action Alternative

Additional disturbance or removal of vegetation will be avoided under this alternative since mine activities will cease with the completion of currently permitted mining operations. Total disturbance will be 2,336 acres. Plant species diversity in the reclaimed community will be less than in the surrounding native plant communities.

After mine operation, the majority of the mine components will be revegetated. Of the 2,336 acres of vegetation to be disturbed through currently permitted mining operations, 1,892 acres will be revegetated and 208 acres (177 acres in the pit and 31 acres of roads outside of disturbance boundary) will not be revegetated. An additional 236 acres will be left undisturbed or are already seeded and reclaimed. Acreages of specific vegetation types that have been removed by currently permitted mining activities could not be calculated since this information was not collected prior to development. However, it is assumed that these development activities affected roughly the same vegetation types as the Proposed Action and other alternatives.

Two seed mixes will be used to revegetate disturbed land (see Tables II-9 and II-10). Successful revegetation of disturbed land is anticipated to occur approximately 3 to 5 years after reclamation. Three to 5 years following reclamation, canopy cover provided by grasses, forbs, and shrub seedlings within the reclaimed areas will likely be similar to canopy cover present in adjacent reference areas located outside of the disturbance area. In addition, these reclaimed plant communities will have a low species diversity that will be substantially lower than the species diversity present prior to the initiation of mining operations. Species diversity will slowly increase over a long period of time. The reclaimed plant communities will likely consist of adequate canopy cover and productivity to substantially reduce the potential for soil erosion and provide forage for use by livestock and wildlife.

Based on the surrounding vegetation types, savannah, coniferous forest, and mixed

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shrub/grassland vegetation types likely occurred in the disturbance area prior to the initiation of mining activities. The majority of trees associated with the savannah and coniferous forest types are mature Rocky Mountain junipers. Mature Rocky Mountain juniper and limber pine trees are approximately 25 to 100 years old. The savannah and mixed shrub/grassland types include mature shrubs which are approximately 15 to 50 years old. The removal of mature trees and shrubs will be a long-term impact since it will take approximately 25 to 50 years after reclamation to establish mature Rocky Mountain juniper and limber pine trees and approximately 15 to 20 years after reclamation to establish mature shrubs in the reclaimed areas.

Rocky Mountain juniper, limber pine, and Douglas fir seedlings will be planted after forbs and grasses have become established in the reclaimed areas. Tree seedlings will be planted at a density of approximately 35 seedlings per acre (range - 20 to 50 seedlings per acre). The densities of trees within the proposed disturbance area greater than 1-inch dbh is 179 trees per acre (Rocky Mountain juniper - 150 and limber pine - 29). Therefore, the seedling planting density will be 144 trees per acre fewer than prior to mine expansion activities. The goal of GSM's tree and shrub planting program is to provide islands of trees from which future tree and shrub establishment will occur.

The weed control program will reduce the potential for noxious weed establishment in the proposed disturbance area during and after mine expansion activities (Section II.B.1.a, Current Mining Operations). However, minor populations of weedy species, such as Canada thistle, white top, spotted knapweed, dalmatian toadflax, and leafy spurge have become established in localized areas. Weedy species rapidly invade disturbed areas and hinder the establishment of more desirable perennial grasses and forbs by competing with them for moisture during the initial years following disturbance or seeding. GSM's goal is to limit establishment of noxious weeds as much as possible during mine operations. The results of each years' weed control activities are detailed in GSM Annual Reports to the agencies. The agencies do not expect total control, as eradication is impossible and the use of chemicals must be limited to recommended application rates and application frequencies. The increase in noxious weeds in disturbed areas is an unavoidable impact of disturbance. It can only be limited by judicious implementation of weed control programs. GSM has two full time technicians that control weeds each summer. The agencies have concurred that control activities to date are adequate.

Activities through the *Interim Dump Plan* will result in the filling of approximately 0.6 acre of non-wetland WUS (i.e., small, intermittent drainages that only support upland vegetation) (GSM 1996a), for a total of 3.1 acres of non-wetland WUS disturbed (2.5 acres have been disturbed by past mining activities). No wetland WUS will be filled or removed. Impacts to riparian areas will not occur. Also, Sheep Rock Creek will not be filled or disturbed.

Projected water drawdown due to pit dewatering will not likely affect water supply to Sheep Rock and Beaver Springs. Therefore, wetlands present in the Sheep Rock and Beaver Spring areas will not likely be affected. The unnamed spring in St. Paul Gulch also is unlikely to be affected. A slightly greater, but still minimal potential for reduction in surface water flow is projected for Rattlesnake and Bunkhouse Springs. A strong potential for reduced discharge is projected for the Steppan and Steppan Original Springs. The maximum predicted flow reduction is a 28 percent decrease for the Steppan Spring. Long-term effects could be greater than operational effects (see Section IV.B, Water Resources). Spring flows also could be reduced by the proposed groundwater capture system for the West Waste Rock Dump. Sheep Rock and Beaver Springs have a minimal potential to be affected by this system. Steppan and Steppan Original Springs and the unnamed spring in St. Paul Gulch have a strong potential to be affected. Any reduction in surface water flow will likely reduce the areal extent of wetland vegetation present in the spring areas. Species diversity also may decrease as a result of reduced surface water

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flows. Mitigation Measures W-1 and W-5 address these impacts.

IV.D.2 Proposed Action Alternative

Mine expansion would disturb or remove an additional 627 acres of vegetation for a total of 2,964 acres (Table IV-12). Grassland, savannah, and pastureland are the predominant vegetation types that occur within the proposed disturbance area. Mine development and operation would remove or disturb approximately 543.7 acres of grassland, savannah, and mixed shrub/grassland vegetation, which represents 87 percent of the vegetation present in the proposed disturbance area. Mine development and operation also would disturb or remove 83.3 acres of vegetation associated with the pastureland and coniferous forest vegetation types within the proposed disturbance area.

Mine expansion would result in the conversion of savannah, coniferous forest, and shrub-dominated communities to grass/forb-dominated communities. Approximately 180.7 acres of savannah and coniferous forest would be removed as a result of mine expansion. Mine development would remove 106.1 acres of mixed shrub/grassland vegetation. The removal of trees and shrubs from 286.8 acres of savannah, coniferous forest, and mixed shrub/grassland would be a long-term impact.

Vegetation would be removed from the East Waste Rock Dump, buttress expansion, tailings, and plantsite areas. Within the buffer zones, vegetation in areas sustaining regular use by vehicles and heavy machinery would be removed and the soil stripped or pushed aside. Soil would be replaced and the area revegetated during reclamation. Other areas within the buffer zones may be partially buried by waste rock; in these areas the vegetation also would be removed and the soil stripped, and the areas would be reclaimed and revegetated as waste rock dump slopes.

After mine operation, the majority of the mine components would be revegetated. A total of 2,964 acres of vegetation would be removed of which 2,506 acres would be revegetated and 259 acres (235 acres in the pit and 24 acres of roads outside of disturbance boundary) would not be revegetated. An additional 199 acres would be left undisturbed or are already seeded and reclaimed.

GSM's existing weed control program would continue under the Proposed Action. Impacts resulting from potential noxious weed infestations and reductions in species diversity within the proposed disturbance area are described in Section IV.D.1, No Action Alternative.

Activities under the Proposed Action would result in the filling and excavation of approximately 1.8 acres of non-wetland WUS (i.e., small, intermittent drainages which only support upland vegetation) (GSM 1996a), for a total of 4.9 acres of non-wetland WUS disturbed by mine activities (3.1 acres will have been disturbed through past mining activities and completion of the *Interim Dump Plan*). Appendix N details project compliance with guidelines of the Clean Water Act Section 404(b)(1) and outlines mitigation measures initiated to compensate for unavoidable adverse impacts to WUS resulting from the Proposed Action.

No wetland WUS would be filled or removed under the Proposed Action. The Bunkhouse Spring wetland is located within the buffer zone for the buttress expansion area, but would not be impacted by mine expansion activities. Potential sedimentation impacts to this wetland would be avoided or minimized with the implementation of the protection measures described in the Storm Water Pollution Prevention Plan. A 0.8-mile segment of Sheep Rock Creek would be filled with the expansion of the East Waste Rock Dump. However, this activity would not impact riparian vegetation or wetlands since riparian and wetland vegetation is not present along Sheep Rock Creek. No riparian areas occur within the proposed disturbance area. Therefore, impacts to riparian areas would not occur as a result of mine expansion activities.

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Table IV-12

Acres of Vegetation Removed Within the Proposed Disturbance Boundary

Mine Component	Vegetation Type					Total
	Grassland	Savannah	Pastureland	Mixed Shrub/ Grassland	Coniferous Forest	
East Waste Rock Dump	196.3	103.7	0	53.4	5.6	359.0
Buttress Expansion	41.0	55.7	0	42.8	1.5	141.0
Tailings Area/Future Borrow Area	17.3	0.5	76.2	0	0	94.0
Plant Site Area	9.4	13.7	0	9.9	0	33.0
Total	**264.0**	**173.6**	**76.2**	**106.1**	**7.1**	**627.0**

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Projected water drawdown due to pit dewatering would not likely reduce surface water flows at Sheep Rock and Beaver Springs. Therefore, wetlands present in the Sheep Rock and Beaver Spring areas would not likely be affected. The unnamed spring in St. Paul Gulch also would unlikely be affected. Minor to moderate reductions in surface water flow are projected for Rattlesnake and Bunkhouse Springs. Steppan and Steppan Original Springs are likely to experience reduced flows. Long-term effects of pit dewatering could be greater than operational effects (see Section IV.B, Water Resources). The potential for reduced spring flows resulting from the proposed groundwater capture system for the West Waste Rock Dump would be minimal for Sheep Rock and Beaver Springs. Steppan and Steppan Original Springs and the unnamed spring in St. Paul Gulch would have a strong potential to be affected. Reductions in surface water flow would likely reduce the areal extent of wetland vegetation present in the spring areas. Species diversity also may decrease as a result of reduced surface water flows. There is a potential for surface water flows to be lost due to pit dewatering at Steppan and Steppan Original Springs. The cessation of surface water flows at these springs would eliminate the established wetland vegetation. Mitigation Measures W-1 and W-5 address these impacts.

IV.D.3 Return Diversion Alternative

General impacts to vegetation, wetlands, and WUS would be the same as discussed in Section IV.D.2, Proposed Action Alternative, except this alternative would result in an additional loss of 2.5 acres of mixed shrub/grassland and grassland vegetation. Therefore, a total of approximately 630 acres of vegetation would be disturbed or removed. Implementation of this alternative would result in the conversion of approximately 180.7 acres of savannah and coniferous forest vegetation and 106.1 acres of shrub-dominated communities to grass/forb-dominated communities. The acreage of savannah and coniferous forest vegetation disturbed or removed would be the same as the Proposed Action.

After mine operation, the majority of the mine components would be revegetated. A total of 2,967 acres of vegetation would be removed of which 2,508 acres would be revegetated and 259 acres (235 acres in the pit and 24 acres of roads outside of the disturbance boundary) would not be revegetated. An additional 199 acres would be left undisturbed or have already been seeded and reclaimed. Discussions regarding the reclamation plan, tree seedling planting program, potential impacts to wetlands, species diversity impacts, and noxious weed control program are the same as discussed in Section IV.D.1, No Action Alternative.

Impacts to wetland and non-wetland WUS would be the same as the Proposed Action. Impacts to wetlands related to spring drawdown would be the same as described for the Proposed Action.

IV.D.4 Divided Dump Alternative

The total acreage of vegetation and non-wetland WUS that would be impacted under this alternative is currently undetermined, as the agency may select one or more of several alternative waste rock disposal areas. Acres of vegetation to be removed within these areas and other mine components are presented in Table IV-13. Potential locations for waste rock disposal the East Waste Rock Dump area include Areas A, B1, and B2 (see Chapter II, Map II-3). Area A would remove approximately 3.0 acres of coniferous forest vegetation. Area B1 would remove approximately 240 acres of vegetation, of which 117.6 acres is grassland, 93.6 acres is savannah, and 28.8 acres mixed shrub/grassland vegetation. Area B2 would remove approximately 270 acres of vegetation, of which 112.3 acres is grassland, 104.6 acres is savannah, and 53.1 acres is mixed shrub/grassland vegetation. Development of the land bridge associated with the East Waste Rock Dump would remove 59.0 acres of vegetation which includes 40.1 acres of grassland, 14.8 acres of savannah, and 4.1 acres of mixed shrub/grassland vegetation.

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Table IV-13

Acres of Vegetation Removed Within the Divided Dump Disturbance Boundary

Mine Component	Vegetation Type					Total
	Grassland	Savannah	Pastureland	Mixed Shrub/ Grassland	Coniferous Forest	
East Waste Rock Dump:						
Area A	0	0	0	0	3.0	3.0
Area B1	117.6	93.6	0	28.8	0	240.0
Area B2	112.3	104.6	0	53.1	0	270.0
Land Bridge	40.1	14.8	0	4.1	0	59.0
West Waste Rock Dump:						
Area C1	18.8	152.9	0	41.5	46.8	260.0
Area C2	61.5	57.2	0	17.8	2.5	139.0
C1 Haul Road	0	9.5	0	27.2	1.3	38.0
Buttress Expansion	41.0	55.7	0	42.8	1.5	141.0
Tailings Area/Future Borrow Area	17.3	0.5	76.2	0	0	94.0
Plant Site Area	9.4	13.7	0	9.9	0	33.0
Total - Minimum Scenario	129.2	127.1	76.2	70.5	4.0	407.0
Total - Maximum Scenario	220.1	189.3	76.2	109.9	4.5	600.0

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Potential locations for waste rock disposal in the West Waste Rock Dump area include Areas C1 and C2. Area C1 would remove approximately 300 acres of vegetation, of which 18.6 acres is grassland, 192.9 acres is savannah, 41.5 acres is mixed shrub/grassland, and 46.8 acres is coniferous forest vegetation. Area C2 would remove approximately 129.0 acres of vegetation, of which 51.5 acres is grassland, 57.2 acres is savannah, 17.8 acres is mixed shrub/grassland, and 2.5 acres is coniferous forest vegetation. Development of the C1 Haul Road associated with the West Waste Rock Dump would remove 38.0 acres of vegetation which includes 9.5 acres of savannah, 27.2 acres of mixed shrub/grassland, and 1.3 acres of coniferous forest vegetation.

Vegetation removed in the buttress, tailings, and plantsite expansion areas is the same as described for the Proposed Action Alternative (see Section IV.D.2). Under the minimum disturbance scenario, 407 acres of vegetation would be disturbed (including development of Area C2, and expansion of the buttress, tailings, and plantsite areas). Under the maximum disturbance scenario, 600 acres of vegetation would be disturbed (including development of Areas A, B2, and the land bridge, and expansion of the buttress, tailings, and plantsite areas). Areas not revegetated would include 235 acres in the pit and 31 acres of roads outside the disturbance boundary.

Discussions regarding the reclamation plan, tree seedling program, species diversity impacts, and noxious weed control program are the same as those discussed in Section IV.D.1, No Action Alternative.

Acres of WUS potentially impacted by this alternative are presented in Table IV-14. All of these areas are non-wetland WUS. No wetland WUS would be filled or removed. Under the minimum scenario, 0.71 acre WUS would be disturbed; under the maximum scenario, 0.94 acre WUS would be disturbed. The actual WUS disturbed under this alternative would depend on the waste rock areas selected, and could be greater or less than the minimum and maximum scenarios. A segment (approximately 1,500 feet) of Sheep Rock Creek would be filled with the construction of the land bridge. A culvert or rock drain would be placed within the original Sheep Rock Creek channel under the land bridge along the 1,500-foot length to allow continued water flow within the creek. This activity would not impact riparian vegetation or wetlands since riparian and wetland vegetation is not present along Sheep Rock Creek. Impacts to wetlands related to spring drawdown would be the same as described for the Proposed Action.

IV.D.5 2:1 Slope Alternative

General impacts to vegetation would be the same as discussed in Section IV.D.2, for the Proposed Action, except this alternative would result in an additional loss of 114 acres of vegetation (Table IV-15), for a total of approximately 741 acres of vegetation disturbed or removed. Implementation of this alternative would result in the conversion of approximately 228.1 acres of savannah and coniferous forest vegetation and 125.4 acres of shrub-dominated communities to grass/forb-dominated communities. Therefore, mine activities associated with this alternative would disturb or remove an additional 47.4 acres of savannah and coniferous forest vegetation relative to the Proposed Action. This alternative also would disturb or remove an additional 19.3 acres of mixed shrub/grassland vegetation relative to the Proposed Action.

After mine operation, the majority of the mine components would be revegetated. A total of 3,079 acres of vegetation would be removed of which 2,621 acres would be revegetated and 259 acres (235 acres in the pit and 24 acres of roads outside of disturbance boundary) would not be revegetated. An additional 199 acres would be left undisturbed or have already been seeded and reclaimed. Discussions regarding the reclamation plan, tree seedling planting program, potential impacts to wetlands, species diversity impacts, and noxious weed control program are the same as discussed in Section IV.D.1, No Action Alternative.

An additional 2.3 acres of non-wetland WUS would be impacted under this alternative, for a total of 5.4 acres of non-wetland WUS affected.

Other impacts to wetland and non-wetland WUS would be the same as described for the Proposed Action. Impacts to wetlands related to spring drawdown would be the same as described for the Proposed Action.

IV.D.6 No Pit Pond Alternative

Impacts to vegetation, wetlands, and WUS would be the same as those described for the Proposed Action Alternative (see Section IV.D.2).

IV.D.7 Partial Backfill Alternative

Impacts to vegetation, wetlands, and WUS would be the same as those described for the Proposed Action Alternative (see Section IV.D.2), except that an additional 225 acres in the pit would be revegetated. Therefore, a total of 2,741 acres would be revegetated under this alternative compared to 2,506 acres under the Proposed Action Alternative, leaving only 24 acres of road areas not revegetated.

Table IV-14

WUS Acreage Impacted by Waste Rock Dump Areas Under the Divided Dump Alternative

Waste Rock Area	Net WUS Acreage
East Waste Rock Dump	
Area A	0.00
Area B1	1.08
Area B2	0.54
Land Bridge[1]	0.40
West Waste Rock Dump	
Area C1	0.77
Area C2	0.71
C1 Haul Road	0.05

[1] Disturbance from the land bridge (0.29 acre dump area, 0.11 acre access road) is considered temporary, as the structure would be removed following mine closure.

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Table IV-15

Acres of Vegetation Removed Within the 3:1 Slope Alternative Disturbance Boundary

	Vegetation Type					
Mine Component	Grassland	Savannah	Pastureland	Mixed Shrub/ Grassland	Coniferous Forest	Total
East Waste Rock Dump	201.7	102.8	16.6	54.2	5.7	381.0
West Waste Rock Dump	25.3	40.5	0	18.5	7.7	92.0
Buttress Expansion	41.0	55.7	0	42.8	1.5	141.0
Tailings Area/Future Borrow Area	17.3	0.5	76.2	0	0	94.0
Plant Site Area	9.4	13.7	0	9.9	0	33.0
Total	**294.7**	**213.2**	**92.8**	**125.4**	**14.9**	**741.0**

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IV.E WILDLIFE AND FISHERIES RESOURCES

IV.E.1 No Action Alternative

IV.E.1.a Habitat Loss

Three general impacts to wildlife resources are occurring as a result of habitat disturbance and loss under the No Action Alternative. These are: 1) direct loss or disturbance to forage, breeding areas, and thermal cover; 2) indirect impacts from displacement of some animals from the mine area into adjacent habitats; and 3) further fragmentation of wildlife habitats from mining activities. Total surface disturbance at the end of the No Action Alternative will be approximately 2,336 acres (see Chapter II, Table II-1).

Generally, disturbance of native habitats in the mine area has resulted in the direct loss of less mobile species (e.g., small mammals, bird nestlings, reptiles) and the displacement of more mobile species (e.g., medium-sized mammals, adult birds, and some big game animals). Habitat removal and disturbance from mine development has affected nesting or breeding habitat, foraging areas, and cover, resulting in fragmentation of habitats suitable for supporting wildlife species. Closure or disturbance of any shafts, adits, or other underground workings associated with past mining activities could have resulted in loss of habitat for bats, in addition to other nongame species such as passerine birds, amphibians, and reptiles. Migratory birds have been exposed to toxic waters associated with the mine. Wildlife use of undisturbed habitats within the mine area has been limited by constant human activities associated with mine operations, including a wildlife hazing program implemented by GSM to minimize wildlife exposure to toxic solutions in the tailings impoundments.

Effects to important habitat include animal displacement, increased competition, and exceedence of carrying capacities within the adjacent habitats. In contrast to these general impacts to wildlife resources, mule deer have habituated to mining operations, and population levels have been increasing in the mine area. Effects to mule deer habitat include animal concentration, increased competition, and exceedences of carrying capacities within the mine permit boundaries, resulting in habitat degradation. For species other than mule deer, loss of habitat and effects to carrying capacities will continue to occur under the No Action Alternative until successful reclamation is achieved. Displaced individuals may or may not be able to establish territories in adjacent habitats, depending on variables such as the species' behavior, density, and individual habitat requirements and availability.

IV.E.1.b Water Resource Impacts

Water quality- and quantity-related impacts to area wildlife species associated with the No Action Alternative are based on the hydrology analysis presented in Section IV.B, Water Resources. As stated in Section IV.B, the waste rock dump designs, retention berms, and surface water diversion structures described in the Operating Permit (GSM 1995a) are expected to adequately manage existing surface water flows.

As a result of pit dewatering, some springs could experience reduced flows or cease flowing on a long-term basis, potentially reducing available surface water sources for wildlife in the mine area. Reduced flow is unlikely or minimal at Sheep Rock and Beaver Springs and the unnamed spring in St. Paul Gulch. There is a slightly greater, but still minimal potential for significant flow reductions at Rattlesnake and Bunkhouse Springs. The Steppan and Steppan Original Springs, have a strong potential for reduced discharge, with the Steppan Spring having the greatest potential. A flow reduction on the order of 28 percent was estimated for Steppan Spring (all other springs would have smaller reductions). However, because water issuing from the Steppan Spring is characterized as having a naturally occurring low pH, the loss of this water source will not represent an impact to wildlife in the area. The Steppan Original Spring has less potential for reduced flow than the Steppan Spring, but the water has a more neutral pH; therefore, reduced flow could represent an impact on wildlife use of the spring. The water quality in the unnamed spring is unknown, but reduced flow could impact its use by wildlife. Mitigation Measure W-1 would address potential impacts to wildlife associated with reduced flows at area springs.

Cyanide levels in Tailings Impoundment No. 1 have been maintained below 50 ppm since the ground movement in 1994. Cyanide levels in Tailings Impoundment No. 2 in March 1996 were 286 ppm. Cyanide levels in the tailings impoundments will remain constant until Tailings Impoundment No. 1 is decommissioned and the new INCO/SO_2 cyanide destruction system reduces cyanide concentrations in Tailings Impoundment No. 2 to levels considered safe for wildlife (expected by mid-1998). Cyanide concentrations of 25 to 50 ppm or less would be required to minimize wildlife mortalities (USFWS 1991); the cyanide destruction system is expected to reduce levels to below 30 ppm. The hazing and monitoring program and the fencing and passive exclusion measures described under Environmental Protection Measures in Section II.B.1.b, Existing Reclamation Plan, will remain in place and further minimize the possibility of wildlife exposure to the tailings impoundments until cyanide levels are reduced. In addition, the fence around the seepage collection pond below the ore stockpile area will prevent deer from entering the pond area where the slick pond liner could pose a hazard.

Following completion of pit excavation, a shallow lake of poor quality water is expected to form at the bottom of the mine pit. This lake will form over a period of several years, and will reach an equilibrium size of 1 to 4 acres. Waterfowl and bats may be attracted to the pit lake as a potential water supply or foraging area, and could come into contact with the poor quality water. The potential for this would increase if the lake supports benthic insects, which animals such as bats might feed on. The lake could, if sufficient nutrients are available, support primary producers and, subsequently, primary consumers such as benthic insects (e.g., chironomids). This is considered unlikely, however, due to the anticipated poor quality of the pit water. Crevices in the pit walls also might provide appropriate habitat for bat roosting, further attracting them to the area. Mitigation Measure WF-1 addresses the impacts of bat and avian foraging over pit water. Other animals may be attracted to the shallow pit lake. However, given the distance to the water, the exclusion measures, and the availability of nearby water resources (Boulder and Jefferson Rivers), it is highly unlikely that large mammals will frequent the lake. No wetland or riparian habitat areas occur within the pit disturbance area.

No wildlife impacts are expected to occur as a result of sludge disposal from the permanent water treatment plant (to be constructed following mine closure). As described in GSM's revised sludge disposal plan (see Appendix C), active sludge disposal cells will be surrounded by wildlife control fences (at least 8 feet high) to prevent large mammals from gaining access to the sludge cells. Water reclaim ponds will be covered with netting to prevent birds from accessing water in the ponds. At least two cells will be active at any time to allow sludge disposal in one cell while the upper lift in the second cell is disked, dried out, or compacted. This process is expected to prevent revegetation from occurring in the disposal area. As discussed in the risk assessment conducted for the proposed sludge disposal system (see Appendix O), the access restrictions and lack of vegetation will prevent the formation of a complete exposure pathway. Therefore, the sludge treatment cells will not represent an adverse impact to wildlife. This impact analysis is dependent upon maintenance of the proposed facilities and institutional controls, including wildlife fencing, water collection, sludge disking, and capping at closure. If these control systems were to fail, the potential for impacts to wildlife could increase.

IV.E.1.c Long-Term Impacts

At the end of mine reclamation under the No Action Alternative, 2,128 disturbed acres will be revegetated. Successful revegetation with alternative forage and cover sources will minimize the long-term impacts to wildlife resources. However, diversity of plant species will be greatly reduced in reclaimed plant communities, representing a reduced diversity of wildlife habitats. In addition, because of the loss of woody species, the reclamation of this previously disturbed land will benefit primarily those species typically associated with herbaceous vegrtation, until woody species are re-established. Noxious weeds will increase in disturbed areas, even with aggressive control programs. These are unavoidable impacts of disturbance. Restoration of wildlife habitat will be enhanced through the use of predominately native, agency-approved seed mixes. As vegetation is re-established, habitat quality, including development of shrub cover, and creation of habitat diversity, will improve and long-term impacts to wildlife resources will be minimized. As human activity in the area decreases and revegetation occurs, wildlife use of the area will likely increase. Waterfowl occurrence in the mine area and the associated impacts of potential contact with contaminated water sources such as the tailings impoundments will decrease as these water sources are eliminated. However, the pit lake will remain, and the potential impacts noted in Section IV.E.1.b above will continue.

As discussed in Section IV.B.1, Water Resources, No Action Alternative, ARD from the waste rock dumps constructed under the No Action alternative is expected to have long-term impacts to groundwater quality, which could result in adverse impacts to aquatic life in the Jefferson River and to several area springs which provide water sources for wildlife. The Steppan Spring, Steppan Original Spring, and the unnamed spring in St. Paul Gulch, have a high likelihood to be impacted by long-term ARD from the West Waste Rock Dump. In addition, the proposed groundwater capture system for the West Waste Rock Dump could cause reduced flows in Steppan and Steppan Original Springs and the unnamed spring. This would impact wildlife utilizing these springs, except the Steppan Spring which already has a low natural pH and is not utilized by wildlife. ARD from the East Waste Rock Dump could impact water quality in the Rattlesnake and Bunkhouse Springs (more likely for the Bunkhouse Springs), impacting wildlife utilizing these water sources. Implementation of the Water Management Plan presented in Appendix A and the measures described in Mitigation Measure W-4 will minimize potential long-term ARD impacts to fishery resources in the Jefferson River and to area springs. Mitigation Measures W-1 and W-5 address the potential impacts to spring water quality and quantity caused by waste rock dump ARD and the groundwater capture system.

Spring flow reductions due to pit dewatering may be greater over the long-term than the reductions estimated to occur during mine operations, due to delayed equilibration of groundwater levels; this represents a potential long-term impact to wildlife species utilizing surface water resources in the mine area. The extent of these impacts depends on the actual amount of water quantity reductions that occur. The impacts of reduced spring flows are addressed in Mitigation Measure W-1.

IV.E.2 Proposed Action Alternative

IV.E.2.a Habitat Loss

The Proposed Action Alternative would result in the loss of an additional 627 acres of previously undisturbed habitat, creating both direct and indirect impacts to wildlife resources and their habitats. Direct effects, including animal displacement, increased competition, and habitat fragmentation, would occur as described for the No Action Alternative, but over a larger impact area, and for a longer duration. Effects would continue for approximately 10 years following completion of the *Interim Dump Plan*.

The hunting territories of raptors and mammalian predators would be reduced by the amount of disturbance to native habitats associated with the mine area expansion, likely affecting small numbers of local predators (e.g., coyote, badger, bobcat). Because suitable habitat for these species exists adjacent to the mine area and because most predators are wide-ranging, it is not likely that the loss of hunting range and associated prey base resulting from the Proposed Action would result in long-term population effects.

No major issues relative to area game species were identified for the Proposed Action Alternative. Individuals would be expected to move out of the mine area during operation into adjacent habitats. However, due to the limited use of the habitats in and around the mine area, few game species would be directly or indirectly affected. Although the proposed mine expansion would remove mule deer habitat, resident deer would be expected to continue using undisturbed and agricultural habitat adjacent to the mine facilities, as they appear to have developed somewhat of a tolerance for existing mining activity levels. The additional loss and disturbance of wildlife habitats associated with the mine expansion also would affect the scattered pronghorn, sharp-tailed grouse, mourning dove, gray partridge, and various migrant waterfowl and shorebirds that may periodically use the area. However, no primary breeding, foraging, or roosting sites for game species would be impacted by the Proposed Action.

Shafts, adits, or other underground workings that are associated with past mining activities may support bats, in addition to other nongame species such as passerine birds, amphibians, and reptiles. Loss of underground openings occupied by bats could be important, particularly if any of the seven sensitive bat species identified as potentially occurring in the area were present (see Table III-4). The disturbance of underground openings from either direct (e.g., removal or closure) or indirect (e.g., noise from blasting) mining-related activities could result in abandonment of important roost sites. Impacts to bats are discussed in more detail in Section IV.F, Threatened, Endangered, and Candidate Species. Mitigation Measure WF-2 addresses these potential impacts.

The historic raptor nest in the large limber pine located north of the tailings impoundments would be removed by the Proposed Action. Although no birds appeared to occupy this nest during the 1994 or 1995 breeding season, a pair of red-tailed hawks have been observed on or near the nest. Nest removal during the breeding season could result in loss of annual productivity for breeding raptors, if the nest were active. In addition to the direct impact to this known nest site, the Proposed Action Alternative would restrict any raptor nesting and foraging in and near the mine area during the life of the project, potentially resulting in short-term habitat loss for breeding and foraging raptors. Mitigation Measure WF-3 addresses impacts to raptor nesting habitat (see Section IV.P.5). Based on GSM's committed measures, the loss of nesting habitat also would be partially offset by construction of the raptor cavities and ledges in the pit highwall, as described under Wildlife Habitat Enhancement in Section II.B.1.b, Existing Reclamation Plan.

No new power line-related impacts to raptor species would result from the Proposed Action. The potential for avian line strikes and electrocution would be the same as the current level, since no new lines would be constructed (see Section II.B.2.a, Proposed Mining Operations).

Another wildlife issue is the impact to breeding song birds, including neotropical migrants, from habitat alteration or destruction. This issue is often emphasized, relative to passerines, as natural bird surveys annually record declining songbird populations (see Section III.E.1.d, Upland Game Birds and Other Land Birds). The anticipated loss of the 274 acres of undisturbed grassland habitat would reduce the amount of potential nesting habitat for ground-nesting birds and those that typically nest in low shrubs. This anticipated habitat loss would not be considered significant to either resident or migratory avian populations because neither of these habitat types are limited in extent within the project region. However, the timing of vegetation and soil removal would have varying effects on the area. Should the habitat removal occur during the incubation and brood-rearing period (approximately May 1 through July 31) not only loss of habitat but loss of the year's reproductive potential would occur. Soil and vegetation removal outside of this time period would only result in loss of habitat. The loss of adult breeding birds, nestlings, or eggs of migratory birds would be a violation of the Migratory Bird Treaty Act. Mitigation Measure WF-4 addresses these potential impacts.

The peak work force is expected to remain approximately 200 employees during mine operation (see Section IV.J.2, Proposed Action Alternative, of Social and Economic Resources). Therefore, no additional direct or indirect impacts to wildlife resources would be anticipated from increased human use and presence, increased noise, or increased traffic, since these operational components are not expected to change from current levels for the Proposed Action.

IV.E.2.b Water Resource Impacts

Water quality- and quantity-related impacts to area wildlife species associated with the Proposed Action Alternative are based on the hydrology analysis presented in Section IV.B, Water Resources. The types of impacts anticipated would be similar to those described for the No Action Alternative.

With the expansion of the East Waste Rock Dump, flow from the Sheep Rock Creek drainage would be diverted into the Conrow Creek drainage. This would increase the drainage area of the Conrow Creek basin, increasing flow levels, and potentially resulting in streambank erosion and/or sediment deposition. No impacts to fisheries would occur as a result. Any increased sedimentation in this ephemeral drainage would not be expected to impact fish in the Boulder River because Conrow Creek drains into pastureland on the east side of Highway 69, and is intercepted by an irrigation canal; no flow to the Boulder River has ever been documented from Conrow Creek. Increased channelization in Conrow Creek could potentially impact transportation corridors for species such as mule deer. This could affect animal movement patterns in the area, but it is not expected to be a significant impact. Potential erosion impacts in Conrow Creek are addressed in Mitigation Measure W-3.

Impacts to wildlife from the tailings impoundments would generally be as described for the No Action Alternative. The existing wildlife hazing and monitoring program, fencing and passive exclusion measures, and the INCO/SO$_2$ system for cyanide destruction would minimize the potential for wildlife exposure at the tailings impoundments. The hazing program would continue until the tailings impoundments are dewatered. There would be no impacts from the sludge disposal system, as described for the No Action Alternative.

Pit water quality would not be expected to change under the Proposed Action. The potential impacts to wildlife would be the same as described for the No Action Alternative (see Section IV.E.1.a). However, the expected equilibrium surface area of the pit lake would be much larger (a maximum of approximately 37.6 acres), increasing the likelihood of wildlife use of the area. Monitoring and hazing efforts may be necessary at the pit following mine operations in order to prevent bat and avian foraging over the pit water and to prevent waterfowl from landing on the pit lake. Mitigation Measure WF-1 addresses these impacts.

There is greater potential for reduced flows in area springs under the Proposed Action than under the No Action Alternative, due to increased pit drawdown (discussed in Section IV.B, Water Resources). Beaver and Sheep Rock Springs and the unnamed spring in St. Paul Gulch are the least likely to experience reduced flows. Flows may be reduced at Rattlesnake and Bunkhouse Springs, but they are unlikely to cease flowing. Steppan and Steppan Original Springs, are likely to experience reduced flows. As a worst-case scenario, the Steppan and Steppan Original Springs would cease flowing. As described for the No Action Alternative, due to the naturally acidic water quality in Steppan Spring, reduced flow at this spring would not be considered an adverse impact on wildlife. Reduced flows at other springs could adversely affect wildlife. Mitigation Measure W-1 addresses these impacts.

IV.E.2.c Hazardous Materials Spill Impacts

The probability of a release of hazardous materials (e.g., diesel fuel, sodium hydroxide, sodium cyanide) into a sensitive receptor along the transportation route is discussed in detail in Section IV.K, Hazardous Materials and Wastes.

As presented, the probability of a diesel fuel spill was calculated to be <0.1 spill during the 10-year project operation under the Proposed Action (see Section IV.K.2). The level of impact from a hazardous spill or release to wildlife resources would depend on the size of the spill, time of year, physical characteristics of the site, cleanup and control techniques, and susceptibility of the dominant or important terrestrial or aquatic organisms. The short- and long-term effects to an aquatic system would depend on the amount of material spilled; the buffering capacity of the water, soils, and associated vegetation; and the recharge or dilution of the system. Impacts from a hazardous materials spill could range from temporary loss of vegetation to the widespread loss of riparian habitat and the organisms that are associated with it. Site remediation would be important in keeping adverse impacts short-term and re-establishing the riparian system. Ephemeral or intermittent drainages would not be as sensitive to a release as perennial systems. The extent that upland areas could be affected would depend primarily on the spill response and cleanup plan (see mitigation measures in Section IV.P.11, Hazardous Materials and Wastes).

IV.E.2.d Long-Term Impacts

Under the Proposed Action, 2,705 acres would be revegetated. The effects of revegetation on the long-term minimization of impacts to wildlife would be as discussed for the No Action Alternative (see Section IV.E.1.c). However, reclamation and the associated benefits to wildlife resources under the Proposed Action would occur on a slower schedule than under the No Action Alternative (see Chapter II, Table II-6 and Table II-13). In addition, negative effects such as reduced diversity of plant species and increased noxious weed invasion would be greater under the Proposed Action due to the larger disturbance area.

The long-term impacts of ARD on groundwater quality and its effects on aquatic life in the Jefferson River and water quality in area springs would be similar to the impacts described for the No Action Alternative (see Section IV.E.1.c). The potential impacts to spring flows from the proposed groundwater capture system also would be as described for the No Action Alternative. The long-term impacts of pit dewatering on spring flows, and therefore to wildlife utilizing these surface water resources, are expected to be slightly greater than but similar to the long-term impacts associated with the No Action Alternative, due to the slightly lower pit water surface elevation. Impacts to spring flow quality and quantity are addressed in Mitigation Measures W-1 and W-5.

IV.E.3 Return Diversion Alternative

Impacts to wildlife and fisheries resources under this alternative would be similar to those identified for the Proposed Action. This alternative would result in the loss of an additional 1.8 acres of tree- and shrub-dominated habitat and 0.7 acre of mixed shrub/grassland habitat as compared to the Proposed Action. The potential impacts from increased sedimentation or erosion in Conrow Creek would be eliminated.

IV.E.4 Divided Dump Alternative

Impacts to wildlife and fisheries resources under this alternative would be similar to those identified for the Proposed Action, except that less total area of previously undisturbed habitat would be disturbed. The actual areas disturbed would depend on the waste rock dump areas selected (see Map II-3). Under the minimum disturbance scenario, approximately 220 acres less would be disturbed; under the maximum disturbance scenario approximately 27 acres less would be disturbed than under the Proposed Action. Maintaining the Sheep Rock Creek drainage in place would benefit terrestrial species that use the drainage as a north-south movement corridor.

IV.E.5 3:1 Slope Alternative

Impacts to wildlife and fisheries resources under this alternative would be similar to those identified for the Proposed Action, with an additional 114 acres of previously undisturbed habitat affected. The shallower slopes associated with this alternative would result in slightly increased forage production (see Section IV.C, Soils and Reclamation).

IV.E.6 No Pit Pond Alternative

The No Pit Pond Alternative was formulated primarily to address potential impacts to wildlife, especially waterfowl and raptors, that could result from the ponding of poor quality water in the pit. The elimination of the pit pond would eliminate the potential adverse impacts to birds and small mammals from contact with the pit water. Other impacts to wildlife and fisheries resources under this alternative would be the same as those identified for the Proposed Action.

IV.E.7 Partial Backfill Alternative

Impacts to wildlife and fisheries resources under this alternative would be the same as those identified for the Proposed Action, with the exception that the potential exposure of birds and small mammals to the pit water would be eliminated, and 235 acres of additional wildlife habitat would be revegetated.

IV.F THREATENED, ENDANGERED, AND CANDIDATE SPECIES

The impact assessment for sensitive wildlife species focuses on potential effects to the species identified in Chapter III, Section III.F; applicable project components are discussed where necessary for each species examined. The impact analysis associated with water quality effects is tiered from the previous analysis presented for general wildlife. Detailed discussion of potential impacts to each species is included in the Biological Assessment prepared for this proposed project (see Appendix E).

IV.F.1 No Action Alternative

No impacts to the gray wolf or grizzly bear will occur under this alternative. The dense vegetation and seclusion from human activity preferred by these species do not occur in the mine area. Both of these species could occur in the mine area as populations expand from Yellowstone National Park to the south and the Elkhorn Mountains to the west. However, this is unlikely due to the existing level of human development along the I-90 corridor and Jefferson River valley. Although an occasional gray wolf or grizzly bear could occur in the area, both of these species are likely to avoid the expansion areas during project operations.

Other than the loss of potential foraging habitat, no impacts to the peregrine falcon, northern goshawk, or ferruginous hawk have occurred. The loss of potential raptor nesting habitat would be minimized at mine closure through implementation of the Environmental Protection Measures presented in Chapter II. No additional impacts are anticipated through reclamation under the No Action Alternative. No active nests or eyries occur in the currently permitted mining area, no substantial habitat areas that could support primary prey species have been removed, and both migrant and foraging birds tend to avoid the expansion areas during project operations. Potential impacts to sensitive species attempting to use the tailings impoundments are avoided through implementation of the existing hazing program.

The loss of foraging habitat would be considered insignificant, due to the abundance of similar habitat adjacent to the mine area.

No other direct impacts to wintering bald eagles would result from the No Action Alternative, since no habitat that supports wintering birds will be affected. The probability of a diesel fuel, sodium cyanide, or sodium hydroxide release along transportation routes, particularly near the Jefferson and Boulder River valleys, is discussed in Section IV.K, Hazardous Materials and Wastes. Although this probability is low, a chemical or fuel spill into a water resource could remove prey items of wintering bald eagles and other raptors, thereby preventing foraging birds from using the area until cleanup is completed. This would result in a short-term loss of foraging habitat for eagles along the specific reach impacted by the release. Although contaminated animals (e.g., fish, waterfowl) would be removed by emergency response personnel during the spill cleanup procedures, foraging eagles could come in contact with contaminated prey, potentially resulting in the individual eagle's injury or death. Adverse impacts to a bald eagle would be considered a "take" under the Endangered Species Act, requiring formal consultation with the USFWS. If a hazardous materials spill were to occur, the lead agency would immediately enter into emergency Section 7 consultation with USFWS to minimize any further impacts.

Disturbance of grassland in the mine area has resulted in the short-term loss of potential breeding habitat for the mountain plover and other ground-nesting birds, until reclamation is complete. However, this is not considered a significant impact due to the lack of known occurrence in the project area and the abundance of similar habitat adjacent to the mine area.

As discussed under Water Resources in Section IV.E, Wildlife and Fisheries Resources, the hazing and monitoring program and the fencing and passive exclusion measures described under Environmental Protection Measures in Section II.B.1.b, Existing Reclamation Plan, have minimized the possibility of wildlife exposure to the tailings

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impoundments. Therefore, impacts to the trumpeter swan and other waterfowl and shorebird species will be minimized in the tailings area through completion of currently permitted mining operations and subsequent reclamation. However, formation of the pit pond lake following mine closure represents a potential impact to trumpeter swans and sensitive bat species that may come into contact with the poor quality water in the pit. Mitigation Measure WF-1 addresses this potential impact.

Suitable habitat for the bull trout and Ute ladies'-tresses does not occur in the currently permitted mine area. Therefore, no impacts to these species have occurred, and would not occur through reclamation of the mine area.

IV.F.2 Proposed Action Alternative

Impacts to threatened, endangered, and other sensitive species would be the same as those described for wildlife resources in Section IV.E.2. Overall the anticipated impacts to sensitive species under the Proposed Action would generally be the same as those described for the No Action Alternative in Section IV.F.1, except that an additional 627 acres of previously undisturbed habitat would be affected, representing an incremental increase in the amount of available foraging habitat that could be utilized by sensitive species. However, this habitat loss would not be considered significant because the affected habitat types are not limited in extent within the project region.

The seven sensitive bat species would be impacted if any of these species occupied abandoned shafts or adits disturbed by the Proposed Action. Mitigation Measure WF-2 addresses these potential impacts. If underground openings would be either directly (e.g., removal or closure) or indirectly (e.g., blasting) disturbed by mining-related activities, the BLM would be notified, and an inspection or survey for bats would be conducted prior to the proposed disturbances. Formation of the pit lake under this alternative represents a potential impact to sensitive bat species and trumpeter swans that may come into contact with the poor quality pit water. This is described in Section IV.E, Wildlife and Fisheries Resources. Mitigation Measure WF-1 addresses these impacts.

IV.F.3 Return Diversion Alternative

Impacts to sensitive species would be the same as those described for the Proposed Action.

IV.F.4 Divided Dump Alternative

Impacts to sensitive species would be the same as those described for the Proposed Action, except that less total area of previously undisturbed habitat would be disturbed. The actual areas disturbed would depend on the waste rock dump areas selected (see Map II-3). Under the minimum disturbance scenario, approximately 220 acres less would be disturbed; under the maximum disturbance scenario, approximately 27 acres less would be disturbed than under the Proposed Action. One deep, open mine shaft in the western portion of Section 30 would be directly affected by construction of Area C1, potentially impacting sensitive bat species (see Mitigation Measure WF-2).

IV.F.5 3:1 Slope Alternative

Impacts to sensitive species would be the same as those described for the Proposed Action, with an additional 114 acres of previously undisturbed habitat would be disturbed, representing an incremental impact to the amount of available habitat in the mine area.

IV.F.6 No Pit Pond Alternative

Impacts to sensitive species would be the same as those identified for the Proposed Action, except that the potential for contact with poor quality water in the pit by sensitive species would be removed.

IV.F.7 Partial Backfill Alternative

Impacts to sensitive species would be the same as those identified for the Proposed Action, except that the potential for contact with poor quality water in the pit by sensitive species

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would be removed. Also, 235 acres of additional wildlife habitat would be revegetated.

IV.G AIR QUALITY

IV.G.1 No Action Alternative

Air quality monitoring of particulate matter has been conducted at the Golden Sunlight Mine since the early 1980s. Particulate monitoring by high volume sampler is conducted at two sites within the mine property, one upwind of the project site and one downwind (based on prevailing westerly winds). Monitoring over this period has indicated that the Golden Sunlight Mine is in compliance with the national and state of Montana Ambient Air Quality Standards.

As part of the reclamation process, revegetation will be performed. Until vegetation becomes established, fugitive dust will affect local air quality. Specifically, earth-moving activities will create particulate emissions as soil is moved and dumped on the areas to be reclaimed. Wind erosion can be problematic, as the area receives less than 13 inches of precipitation per year, and high winds can pick up particulate matter from loose, bare soil. However, measures currently being employed at Golden Sunlight Mine (including Coherex applied to the tailings impoundments) are expected to control these emissions (see Section III.G.2). Under the No Action Alternative, no further surface disturbance will occur, and fugitive emissions are not expected to exceed existing emission levels. Therefore, no further impacts to the airshed are expected to occur under this alternative. Cessation of all mining and reclamation activities associated with the Golden Sunlight Mine will return particulate emissions to background levels.

IV.G.2 Proposed Action Alternative

Air quality within the region would be nominally affected under the Proposed Action by both construction and operational activities associated with continued mining at the Golden Sunlight Mine. The primary concern would be for particulate emissions generated from continued mining and eventual reclamation. However, no additional equipment would be added to the operations, and throughput would remain at current levels. Therefore, the concern over particulate emissions would not come from an increase in emission rates, but rather from emissions continuing over a longer duration of time. Also, expansion of the current facility under the Proposed Action would involve a larger surface disturbance than if no action were taken. This would increase the fugitive particulate emissions during the time of expansion, and would add to the size of the reclamation effort. The reclamation of the mine would involve storage of greater amounts of soil, which would need to be deposited over a greater area. Until revegetation is accomplished, these areas would be susceptible to wind erosion. However, once vegetation is established, erosion of surface soil should be minimal. Overall, the impact to the airshed from the Proposed Action would be temporary, and no significant long-term impacts would be expected.

Construction activities that may affect the regional air quality include earth moving, blasting, and hauling. During construction, emissions from vehicle exhaust would be generated, but are not expected to impact the regional air quality. Particulate emission levels would increase with construction, but would be transitory, lasting only as long as construction is occurring. Mine operation activities would include blasting, hauling, crushing, and material processing. The primary pollutant of concern would again be particulate matter. Other pollutants such as NO_2, CO, and SO_2 from exhaust emissions of mobile sources also would be generated, yet their impacts would be minimal on the overall ambient air quality.

Under GSM's Air Quality Permit (#1689-04) dated June 11, 1993, all phases of mine operation are examined and environmental protection measures have been clearly identified by which air emissions are to be minimized. Measures such as limiting fall distances for topsoil, overburden, ore and waste removal, transfer and dumping, drilling with skirting and water sprays, and stabilizing topsoil stockpiles and disturbed or exposed areas with chemicals, mulch or revegetation, and many others, are all incorporated into the operating permit and serve to help mitigate the point, area, and fugitive air emissions for the mining activities (GSM 1995a).

Mitigation of fugitive dust emissions from haul roads and access roads would be accomplished through water spray, and water spray with dust suppressants. These suppressants act to adhere smaller dust particles into larger, heavier conglomerates, which are less prone to become airborne. Temporary revegetation of soil stockpiles would alleviate particulate emissions from these sources, especially from wind erosion. Fugitives from the tailings impoundments would be controlled by application of Coherex, as described in Chapter III, Section III.G.2, Air Quality.

IV.G.3 Return Diversion Alternative

Impacts to air quality would be the same as those described for the Proposed Action.

IV.G.4 Divided Dump Alternative

The Divided East Waste Rock Dump Alternative would yield a slightly greater impact to the air quality of the region than the Proposed Action. The increased distance that waste material must be hauled due to the more out-lying locations of alternative waste rock dump areas, would slightly elevate air quality impacts. Longer haul distances increase the fugitive emissions generated by haul truck traffic picking up particulate from the road surface, and the subsequent particulate emissions generated from air blowing over the waste material as it is transported. Construction and the eventual destruction of the land bridge also would slightly increase short-term impacts of fugitive particulate emissions through earth-moving activities. However, emissions would not be expected to exceed state or federal standards.

IV.G.5 3:1 Slope Alternative

Under this alternative, air quality impacts would be slightly greater than under the Proposed Action, due to the increase in surface area affected, and the subsequent increase in soil needed for reclamation. With a greater surface area affected, wind erosion potential would be elevated. However, it is not expected that state and federal air quality standards would be exceeded.

IV.G.6 No Pit Pond Alternative

Air quality impacts would be the same under this alternative as under the Proposed Action, except that emissions associated with pumping water from the pit could be greater. Depending on the type of power used to pump water from the pit, air impacts could range from no significant impact if an electric pump is used to a minimal impact if an internal combustion engine powers the pump. Impacts from an internal combustion powered pump would involve NO_x, CO, and potentially SO_2. Impacts from keeping the pit pumped dry also could involve increased dry surface area, and the subsequent fugitive particulate emissions generated. However, no federal or state air quality standards would be expected to be exceeded.

IV.G.7 Partial Backfill Alternative

The Partial Backfill Alternative would increase fugitive emissions compared to the Proposed Action due to an increase in earth-moving activities. Under this alternative, waste rock would be transported from the East and West Waste Rock Dump to the pit in order to partially backfill the pit. This would essentially double the fugitive emissions associated with the transport of material, as compared to the Proposed Action. Also, increased fugitive emissions would occur, as material is dumped and worked into the pit. However, it is not expected that federal or state standards would be exceeded.

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IV.H LAND USES AND PLANS

IV.H.1 No Action Alternative

Under the No Action Alternative, additional disturbance to lands within the project area will not occur. Access to the project area will be preserved, and the existing land uses will be maintained. Grazing will continue as it is currently permitted on project area lands, and no loss of AUMs will occur. Range improvements in the Hill and Wilkerson Allotment will not be displaced. The microwave power line right-of-way will not require relocation. Mine operations will cease in 1997 or 1998, and reclamation activities will proceed as per the schedule listed in Table II-6. Project area disturbed lands will eventually be returned to their pre-mining land uses, as described in Section IV.H.2.b, Mine Closure/Reclamation, for the Proposed Action Alternative below.

IV.H.2 Proposed Action Alternative

Potential land use impacts for the Proposed Action include both direct and indirect impacts. Direct impacts may include the termination or modification of existing land uses or access routes in the study area. Indirect impacts may result in altered land use patterns or access to areas adjacent to or within proximity of the Proposed Action. Impacts were evaluated for characteristics such as duration, quantity, and quality. The following criteria were used to determine impacts of the Proposed Action on land use: 1) impacts to state school trust surface and subsurface land; 2) potential conflicts with existing land use plans (e.g., Headwaters Resource Area RMP, Jefferson County Comprehensive Plan); 3) creation of land use incompatibilities; 4) displacement of recreation resources or alteration of use patterns; 5) modification of range uses, including loss of AUMs and displacement of range improvements; 6) displacement or alteration of existing transportation infrastructure, or changes in existing traffic levels; 7) disruption or alteration of public access opportunities; and 8) displacement or modification of existing rights-of-way.

IV.H.2.a Mine Development/Operation

Table II-11 shows the acreage and ownership of surface land in the permit boundary and disturbance area of the mine under the Proposed Action. The Proposed Action would involve a 1,054-acre expansion of the mine permit boundary, including 631 acres of GSM land, 323 acres of BLM-administered land, and 100 acres of state school trust land. The total area within the permit boundary would then be 6,125 acres. The disturbance area would expand by 627 acres, including 517 acres of GSM land, 75 acres of BLM-administered land, and 35 acres of state school trust land. The total disturbance area would then be 2,964 acres. For safety and security reasons, public access to the active mining and processing areas would be restricted during the life of the Proposed Action. Other uses of the disturbed land would be precluded for the life of the project.

Disturbance occurring on state school trust surface land under the Proposed Action would include 3 acres for the Sheep Rock Creek diversion, 8 acres for a soil stockpile, and 24 acres for a buffer area, all of which would be non-acid producing and non-permanent types of disturbance associated with the East Waste Rock Dump in Section 16. Use of and access to state school trust mineral estate located below the disturbance area also would be precluded during the life of the mine. Disturbance occurring above state school trust subsurface lands (mineral estate) under the Proposed Action is shown in Table II-12. This disturbance would include a total of 718 acres, including 417 acres of sulfide-covered disturbance, and 301 acres of non-sulfide covered disturbance. This represents a 361-acre increase in disturbance occurring above state school trust subsurface lands over the existing disturbance. Portions of this mineral estate would be leased by GSM for mineral extraction. The MDNRC would require GSM to obtain a land use license and/or a special use lease for other disturbance above state subsurface lands, depending on the type of disturbance. For permanent disturbances,

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condemnation work, compensation, and/or a land exchange would be required.

The Proposed Action is consistent with policies of the BLM's Headwaters Resource Area RMP, which designates all public land as open to mineral entry and development. Proposed mining activities on private lands are consistent with the Jefferson County Comprehensive Plan, which outlines the goal of inviting continued mineral exploration and development. Both documents stipulate that mining should be carried out in such a way that does not adversely impact surrounding properties and that minimizes impacts to natural resources.

Transportation and access routes would not be affected by the Proposed Action. All current access routes would remain open. Transportation use on the roadways would be unchanged by the proposed project. Mine activity is expected to continue at the current rate and traffic levels on mine roadways would, therefore, remain approximately the same. Access to public lands in the new disturbance areas and within the mine permit boundary would be restricted for mine operation and public safety.

The Proposed Action would impact one right-of-way in the project area. The microwave power line would be displaced by the East Waste Rock Dump and buttress. A new right-of-way would be issued to reroute the power line to a location outside of the proposed disturbed areas (Seybert 1996). No other new rights-of-way would be required for the proposed project.

The Proposed Action would impact grazing on lands in the project area. The mine permit boundary would expand to include an estimated additional 430 acres of the Bull Mountain Allotment and 555 acres of the Hill and Wilkerson Allotment. The permit boundary would not be fenced, and grazing would be allowed to continue in many areas not disturbed by mining activity. Other areas would be restricted from grazing use due to proximity to mine facilities. No new acres in the Bull Mountain Allotment would be disturbed under the Proposed Action. Approximately 350 to 400 acres of the Hill and Wilkerson Allotment would be disturbed or restricted from grazing use; this includes 60 acres of state school trust land and 70 acres of BLM-administered land. The grazing loss would include 18 AUMs on the state trust land and 10 AUMs on the BLM-administered land. The stocking rate for the private land portions of the allotment are determined by the private property owners and leaseholders. The area on the east side of the mine, including federal, state, and private lands, is grazed by a herd of 400 cattle belonging to one leaseholder/property owner. Because the area is used only for a short period of time in early spring before the cattle are moved to large pastures available in other areas, it is expected that the loss of grazing acres would not affect the size of the herd; however, it would reduce the early spring pasture available (Seybert 1996).

The Proposed Action would disturb portions of range improvements in the project area. The Sheep Rock pipeline and troughs in the Hill and Wilkerson Allotment would be displaced by the East Waste Rock Dump. GSM would either reroute the pipe through the proposed Sheep Rock Creek diversion channel or would drill additional wells for range use (Seybert 1996). Consequently, the Proposed Action would have no net impact on range improvements.

The Proposed Action would have little or no effect on recreation use in the area. No parks, developed recreation areas, wilderness areas, or protected natural areas would be impacted; dispersed recreational use in the project vicinity is light. No recreation users are expected to be displaced from the area of the proposed permit boundary expansion; the existing Golden Sunlight Mine has most likely already caused recreationists to use other lands. No access routes to recreation areas pass through the mine property or would be restricted by mining activity. A slight impact may occur to some dispersed recreational activities in the region, such as fishing, hunting, and hiking, due to visual disturbance within the project viewshed (see Section IV.I.2.a, Visual Resources under the Proposed Action Alternative). However, these impacts are expected to be minimal.

IV.H.2.b Mine Closure/Reclamation

The closure, abandonment, and reclamation of the Proposed Action would eventually return public (federal and state) lands to their pre-mining land uses as rangeland, wildlife habitat, and dispersed recreation. All surface disturbances within the permit boundary would undergo some form of reclamation activities. All areas, except portions of the mine pit and roads outside the disturbance boundary, would be revegetated. Pre-mining uses would be restricted until sufficient revegetation has occurred, especially in the tailings and waste rock dump areas, where stabilization of top layers is critical for effective reclamation (particularly on steep slopes). Livestock grazing would be resumed after re-established vegetation is capable of supporting grazing, as determined by the administering agencies. Public access would be restored to the area following reclamation, except for the pit, which would be fenced and bermed, with warning signs posted for public safety.

Access to and use of the mineral estate on portions of the disturbed areas would be precluded indefinitely under the Proposed Action. In areas where substantial amounts of waste rock or other permanent structures are placed, the mineral estate would effectively become inaccessible. This is an important issue for state-owned mineral estate, which is managed for the school trust. Waste rock dump disturbance occurring above state school trust subsurface lands would increase by 361 acres under the Proposed Action, for a total of 718 acres (see Table II-12).

IV.H.3 Return Diversion Alternative

The impacts to land use for this alternative would be the same as those described for the Proposed Action, except that an additional 2.5 acres of GSM land would be disturbed by the diversion channel just south of the East Waste Rock Dump. This alternative also provides the option of rerouting the displaced Sheep Rock water pipeline in the Hill and Wilkerson grazing allotment through the diversion channel for Sheep Rock Creek to maintain a water source for range use.

IV.H.4 Divided Dump Alternative

Under this alternative, the disturbance area of mine facilities would depend on which areas are utilized for waste rock disposal (see Map II-3). Not all of the areas displayed would need to be utilized to provide adequate waste rock dump capacity. The agency would select a combination of one or more of the areas, in whole or in part. Table II-15 shows the acreage of new and total surface disturbance of each of the potential waste rock dump facilities under the Divided Dump Alternative. Table II-16 provides the total disturbance area and surface ownership of mine facilities under a minimum and maximum disturbance scenario. The minimum disturbance scenario would involve utilization of Area C2 for waste rock disposal. New surface disturbance would encompass 407 acres (268 acres of GSM or other private land, and 139 acres of BLM-administered land), for a total of 2,743 acres of disturbance for mine facilities. The maximum disturbance scenario would involve utilization of the land bridge and Areas A and B2 for waste rock disposal. New surface disturbance would encompass 600 acres (551 acres of GSM land and 49 acres of BLM-administered land) for a total of 2,936 acres of disturbance for mine facilities. Facilities in the East Waste Rock Dump area are located predominantly on GSM land, except for the land bridge, which occupies mostly BLM-administered land, and Area B1, which occurs on 153 acres of state school trust land. Facilities in the West Waste Rock Dump area are located predominantly on BLM-administered land, except for Area C1, which occupies a small portion of GSM land and 73 acres of state school trust land. The permit boundary would need to be expanded beyond the area for the Proposed Action if Areas B1, B2, C1, or C2 are selected.

Disturbance occurring above state school trust subsurface lands (mineral estate) is shown in Chapter II, Table II-17. Under the minimum disturbance scenario, 448 acres of disturbance would occur above state school trust subsurface lands. Under the maximum disturbance scenario, 726 acres of disturbance would occur above state school trust subsurface lands. A breakdown of disturbance for each alternative waste rock area is provided in the table. Area C2 would not impact state school trust mineral estate. Area C1 would impact 73 acres of state school trust mineral estate, Area B1 would impact 233 acres, Area B2 would impact 268 acres, and the land bridge would impact 10 acres (portions of these are buffer areas and would not be permanent disturbances). Condemnation drilling and analysis of the state school trust mineral estate would be required where permanent structures are placed. If Areas B1 or B2 are utilized, the MDNRC would likely require compensation for the state school trust limestone resource in these areas. If Areas B1 or C1 are utilized, the state may require a land exchange, due to the placement of permanent structures on state school trust surface land as well as mineral estate located in Sections 16 and 36, respectively.

Grazing allotments would be impacted by the Divided Dump Alternative, depending on which areas are selected for waste rock disposal. Area C2 would disturb approximately 135 additional acres of BLM-administered land in the Bull Mountain Allotment, for a loss of 17 AUMs. Area C1 would disturb approximately 55 additional acres of BLM-administered land in the Bull Mountain Allotment, for a loss of 7 AUMs. In addition, 73 acres of state school trust land in Section 36 would be disturbed by Area C1, for a loss of 12 AUMs, and approximately 90 acres of BLM-administered land in Section 31 would be disturbed, for a loss of 8 AUMs on a grazing allotment for horses. The C1 haul road is located outside of the allotment and would not disturb any additional allotment areas. In the Hill and Wilkerson Allotment, Area B1 would disturb 240 additional acres, Area B2 would disturb 270 additional acres, Area A would disturb 3 additional acres, and the land bridge would disturb 59 additional acres. These areas are primarily GSM-owned, except for portions of Area B1 and the land bridge. Area B1 would disturb 153 acres of state trust land in Section 16, for a loss of approximately 31 AUMs. The land bridge would disturb 49 acres of BLM-administered land and would probably preclude grazing in the entire 70-acre BLM-administered section in the allotment for a loss of 10 AUMs. Disturbance of other lands with the Hill and Wilkerson Allotment would reduce the amount of early spring pasture available, but would not affect the size of the herd (as described for the Proposed Action Alternative in Section IV.H.2). With construction of the land bridge under this alternative, the Sheep Rock pipeline could be rerouted through the culvert or drain through the Sheep Rock Creek drainage.

The microwave power line right-of-way would be displaced under this alternative; however, rerouting requirements would be different than under the Proposed Action. The power line would be displaced from the buttress area, as under the Proposed Action, but the rerouting in the East Waste Rock Dump area would be determined by which areas are selected for waste rock dump disposal. Under the minimum disturbance scenario (with no dumps on the east side selected), the power line would not require rerouting around the East Waste Rock Dump. If areas on the east side are selected and the land bridge is constructed, the power line would require rerouting around the land bridge and the dump that is selected.

All other land use impacts would be the same as those described for the Proposed Action.

IV.H.5 3:1 Slope Alternative

The impacts to land use for this alternative would be similar to those described for the Proposed Action, with additional disturbance in the East and West Waste Rock Dumps. Surface disturbance and land ownership for mine facilities under the 3:1 Slope Alternative are shown in Chapter II, Table II-19; disturbance area and reclamation requirements by disturbance type are shown in Chapter II, Table II-21. In the West Waste Rock Dump facility, the dump and haul roads disturbance would be 98 acres greater, and the construction buffer disturbance 6 acres less (net 92 acres more disturbance). In the East Waste Rock Dump facility, the dump and haul roads disturbance would be 27 acres greater, the construction buffer disturbance 22 acres greater, and miscellaneous disturbance 27 acres less (net 22 acres more disturbance). The total disturbance area would be 114 acres greater under the 3:1 Slope Alternative than under the Proposed Action. The 92 additional acres of disturbance in the West Waste Rock Dump would occur on BLM-administered land. The 22 additional acres of disturbance in the East Waste Rock Dump would occur on GSM land. The permit boundary area would be the same as the Proposed Action.

Disturbance occurring above state school trust subsurface lands (mineral estate) would be 23 acres greater under the 3:1 Slope Alternative than under the Proposed Action (see Chapter II, Table II-20). This would include 49 acres more dump and haul roads disturbance (sulfide-covered) and 26 acres less construction buffer disturbance (non-sulfide covered) in the East Waste Rock Dump facility.

Impacts to grazing would be slightly greater than under the Proposed Action. Approximately 21 acres would be disturbed in the Bull Mountain Allotment, for a loss of 3 AUMs. In the Hill and Wilkerson Allotment, an additional 22 acres of GSM land (beyond the Proposed Action disturbance) would be disturbed by the East Waste Rock Dump. This disturbance would further reduce the amount of early spring pasture available, but would not affect the size of the herd, as described in Section IV.H.2, Proposed Action Alternative.

All other land use impacts would be the same as those described for the Proposed Action.

IV.H.6 No Pit Pond Alternative

The impacts to land use for this alternative would be the same as those described for the Proposed Action.

IV.H.7 Partial Backfill Alternative

The impacts to land use for this alternative would be the same as those described for the Proposed Action, except that additional areas of the pit would be reclaimed. The pit would be backfilled to the daylight level and all benches capped with rock and soil, resulting in final contours more closely resembling the original landscape.

IV.I AESTHETIC RESOURCES

IV.I.1 No Action Alternative

IV.I.1.a Visual Resources

Under the No Action Alternative, no additional impacts to visual resources will occur. Current mine disturbance will not be expanded. Areas not in compliance with objectives of the suggested Visual Resource Management (VRM) Class III rating will not be increased. In addition to the planned concurrent reclamation, the remainder of the disturbed areas will be reclaimed beginning after mine closure in 1997 or 1998, as described in the current Operating Permit. Most surface areas will be recontoured, capped with rock and soil, and revegetated. Plant site buildings and other structures will be removed. Recontouring and revegetating of slopes will reduce visual contrasts. The scale of visual disturbance caused by existing man-made forms, particularly the pit terraces and waste rock piles, will remain, but reclamation will soften the contrasts to blend with the more rounded natural landscape forms. Over time, vegetation will begin to restore the color and textures of the existing natural landscape. Visual contrasts will be noticeable but not dominant in the landscape. Landscape modifications will be reduced to a level that is consistent with the suggested VRM Class III rating.

IV.I.1.b Noise

Under the No Action Alternative, noise from the mine site will continue at current levels until 1997 or 1998, when operations will cease. At this time, mining noise will decrease with the discontinuation of blasting, drilling, crushing, loading, and hauling. Some noise will continue to be generated by reclamation activities for the next several years. All mining-related noise will cease when reclamation is complete, with the exception of the permanent water treatment plant, which is expected to operate indefinitely; noise from this facility will be minimal.

IV.I.2 Proposed Action Alternative

IV.I.2.a Visual Resources

Visual impacts have been assessed in accordance with standard BLM VRM contrast rating principles, as outlined in BLM Manual Handbook 8431-1, *Visual Resource Contrast Rating*. The contrast rating process is used to systematically identify the nature and degree of visible modification to the landscape that would occur as a result of a Proposed Action. The degree of contrast is then compared to VRM guidelines for the area to determine the level of impact and compatibility with the assigned VRM class (BLM 1986b).

Because the BLM has not yet assigned a VRM classification for the study area, the suggested VRM Class III rating was used as the reference point for conducting contrast rating analysis. This suggested rating was developed through the Visual Resource Inventory (VRI) conducted as part of the baseline assessment (see Chapter III, Section III.I.1, Visual Resources, and Appendix F, Visual Resource Inventory and Contrast Rating Forms). Objectives for the Class III rating provide for moderate changes to the existing landscape and activities that may attract attention but do not dominate the view of the casual observer (see Chapter III, Table III-9). Areas currently not in compliance would be considered rehabilitation areas.

The extent to which the Proposed Action would affect the visual quality depends upon the amount of visual contrast created between the proposed facilities and the existing landscape features (landform and water, vegetation, and structures). The four elements of form, line, color, and texture are used to describe each feature. The magnitude of change relates to the contrast created in each element for each of the landscape features. The contrasts visible from selected Key Observation Points (KOPs) are recorded on standardized Visual Contrast Rating Worksheets. Management actions that exceed visual management objectives may be required to reduce their overall contrast. Assessing the Proposed Action's contrast in this manner indicates the severity of potential impacts and guides the development of mitigation measures to fulfill VRM objectives (BLM 1986b).

The Proposed Action would be located in an area with extensive previous mining disturbance. Features of the existing Golden Sunlight Mine are visible on the ridge from the east, west, and south. The West Waste Rock Dump is visible to the west and south. The East Waste Rock Dump, the pit highwall, portions of the pit benches and terraces, and the processing facilities are visible to the east. Other portions of the mine are obscured by hills and are not visible from specific KOPs. Existing disturbances contrast strongly with the natural landscape. The angular and geometric forms; sharp horizontal, vertical, and diagonal lines; bright colors of cream, white, and tan; and smooth texture of mining areas are distinct in a visual landscape of softer, rounded natural forms, duller vegetation colors, and rougher textures (see Appendix F, Visual Resource Inventory and Contrast Rating Forms).

Mine Development/Operation

The Proposed Action would create additional mining disturbance and increase the physical extent of visual contrast with the natural environment. Proposed activities would entail the expansion of the current open pit to cover an additional 24 acres; the depth of the pit also would increase, and additional portions of the current side-wall terraces would be removed. The East Waste Rock Dump would expand to the east to cover an additional 359 acres, and pit excavations on the west side of the East Waste Rock Dump would reduce the size of the waste rock dump by 27 acres; the height of the current portion would remain at approximately 5,600 feet, while the new portion would consist of two terraces at heights of 5,360 feet and 5,200 feet. The buttress area would expand to cover an additional 141 acres; it would be constructed to a height of approximately 5,100 feet.

Two KOPs were selected for assessing the potential contrasts created by the Proposed Action. KOP 1 is located on I-90 at the Whitehall exit, approximately 2 miles west of the mine. This location is representative of views for travelers on the Interstate and for residents in and around Whitehall. The West Waste Rock Dump is currently visible from this location and creates a strong contrast with the natural features of the landscape. No changes to the West Waste Rock Dump would occur under the Proposed Action. No other mine activities under the Proposed Action would be visible from KOP 1. Therefore, no visual contrasts would be observed from KOP 1.

KOP 2 is located on Highway 69, approximately 2 miles east of the mine. This location is representative of views from the east side of the mine, including travelers on the highway. The East Waste Rock Dump, the pit highwall and portions of pit benches and terraces, and a portion of the processing facility are currently visible from this location. The form, line, color, and texture of these features contrast strongly with the natural landscape. The Proposed Action would increase these disturbances. Additional excavations in the pit would be visible, which could create more contrasting lines and forms, but the size of the pit would not increase significantly. Large portions of the new extension to the East Waste Rock Dump would be visible; two new, lower terraces would extend to the east. In addition, portions of the buttress also would be visible from the east. These features would be only partially obscured by two small hills on the east side of the mine. The overall degree of contrast from KOP 2 is rated moderate.

Overall, the Proposed Action would repeat the similar modified forms, lines, colors, and textures that presently exist in the study area. The scale of existing landform modifications would increase incrementally with excavation of the pit and construction of the buttress and the larger waste rock dumps. Contrasts visible from the two KOPs are rated none to moderate. These changes are consistent with the objectives of the suggested VRM Class III rating. However, the changes from the Proposed Action were measured in relation to existing disturbances, which contrast strongly with the natural landscape and are not consistent with VRM Class III objectives. Rehabilitation would be required, upon project completion, to restore these areas to a level that complies with a VRM

Class III rating. Any additions to the current disturbance would, then, also require the same level of rehabilitation to restore landscape modifications to Class III objectives.

Mine Closure/Reclamation

After successful reclamation, the visual contrast of the Proposed Action would be reduced. Where feasible, major benches of the pit would be capped with oxide rock and soil, and revegetated. Most of the waste rock dump slopes would be reduced to 2:1. The buttress and some slopes in the East Waste Rock Dump would be reduced to 3:1. All dump slopes would be recontoured to blend with the natural landscape as much as possible, and surfaces would be capped with rock and soil and revegetated. All plant site buildings and other structures would be removed unless another use is found for them; the topography would then be recontoured, capped with rock and soil, and revegetated. Native vegetation would be used as much as possible to blend more naturally with the surrounding landscape.

Recontouring and revegetating would reduce the visual contrast in the landscape. Sharp lines and forms in the pit and waste rock dump areas would be softened. Revegetation of the faces of waste rock dump areas would reduce visual contrasts with surrounding vegetation. Natural vegetation over the long-term would begin to blend with the color and texture of the existing natural landscape. The scale of visual disturbance caused by existing man-made forms would remain, but reclamation would soften the contrast to blend with the more rounded natural landscape forms. The exception would be the pit, where portions of the highwalls and terraces would remain visible. Overall, however, visual contrasts would be reduced to a level where they are noticeable but not dominant in the landscape, following successful reclamation and revegetation. Landscape modifications would be consistent with the suggested VRM Class III rating for the area.

IV.I.2.b Noise

Noise from the mine site would not increase with implementation of the Proposed Action, but the duration would be extended. Existing noise associated with mining operations would continue at the same levels until the end of mine life in 2006. No new disturbances would be introduced to the noise environment. Noise at the nearest sensitive receptors would continue to be dominated by highway and roadway traffic.

After mine closure, mining noise would decrease significantly with the discontinuation of blasting, drilling, crushing, loading, and hauling. Some noise would continue to be generated by reclamation activities such as recontouring, regrading surface areas with rock and topsoil, and dismantling structures. Hazing also would continue in the tailings impoundment areas until the ponds are drained of water and reclaimed. All mining-related noise would cease when reclamation is complete, with the exception of the permanent water treatment plant, which is expected to operate indefinitely; noise from this facility would be minimal.

IV.I.3 Return Diversion Alternative

IV.I.3.a Visual Resources

The visual impacts of this alternative would be the same as those described for the Proposed Action.

IV.I.4 Divided Dump Alternative

IV.I.4.a Visual Resources

The visual impacts of this alternative would depend upon which areas are selected for waste rock disposal. The new disturbances created by the expanded East Waste Rock Dump under the Proposed Action (resulting in moderate visual contrasts observed from KOP 2) would not occur under this alternative. However, additional disturbances would be created by construction of either Area B1 or B2. These areas would create greater visual contrasts from KOP 2, as the areas would extend farther east from the ridge by approximately 0.5 mile and would be more prominent in the landscape. The contrast rating from KOP 2 would likely increase from moderate to moderate-strong (over the Proposed Action rating). This rating is not consistent with the objectives of the suggested VRM Class III rating.

Construction of either Area C1 or C2 in the West Waste Rock Dump facility would increase the visual contrasts from KOP 1. Construction of Area C2 would extend the West Waste Rock Dump approximately 0.25 mile farther west. Because of the viewing angle, visible disturbance would not increase significantly. The visual contrasts from KOP 1 would likely increase from none to weak (over the Proposed Action rating) if Area C2 were selected. This contrast rating would be consistent with the objectives of the suggested VRM Class III rating. However, existing disturbances, which do not comply with the rating, would be increased.

Construction of Area C1 would extend the West Waste Rock Dump approximately 0.25 mile farther west and 0.5 mile farther south of the ridge. Due to the viewing angle at KOP 1, the additional disturbance would create visible changes in the existing landscape. In addition, construction of the C1 haul road would be required to access the C1 dump. The haul road would be constructed at the 5,300-foot level and would create a 250-foot cut on the hillside. Portions of this would be visible from KOP 1. The contrast rating from KOP 1 would likely increase from none to moderate (over the Proposed Action rating), if Area C1 were selected.

Reclamation would restore many of the features of the natural landscape and reduce contrasts; however, the visual disturbances remaining after reclamation under this alternative could potentially be greater than under the Proposed Action, depending on which areas are selected for waste rock disposal. Selection of waste rock dump facilities that are more prominent in the landscape, such as Areas C1, B1, and B2, would add forms and lines that would result in greater contrasts remaining following reclamation.

IV.I.4.b Noise

The noise impacts of this alternative would vary in comparison with the Proposed Action depending on which areas are selected for waste rock disposal. Impacts to residences near the waste rock dump areas would be greater or less depending on proximity to dumping and hauling activities. Under the minimum disturbance scenario, or with selection of only areas on the west side of the mine, the noise impacts would be greater for residences in proximity to the West Waste Rock Dump facility and less for residences near the East Waste Rock Dump facility (as the Proposed Action expansion on the east side would not occur). Under the maximum disturbance scenario, or with selection of only areas on the east side of the mine, the noise impacts would be greater for residences in proximity to the East Waste Rock Dump facility. Noise impacts would not change for residences in proximity to the West Waste Rock Dump facility as no expansion to this facility is proposed.

IV.I.5 3:1 Slope Alternative

IV.I.5.a Visual Resources

The visual impacts of this alternative would essentially be the same as those described for the Proposed Action, except that the 3:1 slope reclamation would change the final contours of visual features in the East, West, and South Waste Rock Dump areas. Visual contrasts following reclamation would most likely be reduced in the East Waste Rock Dump area, as 3:1 slopes blend more naturally with the existing landscape in this area. Visual contrasts following reclamation would likely be slightly greater in the West and South Waste Rock Dump areas, as the natural slopes in this area are 2:1 or steeper. Overall, the visual impacts in relation to the VRM classification would be the same as for the Proposed Action.

IV.1.5.b Noise

The noise impacts of this alternative would be the same as those described for the Proposed Action.

IV.1.6 No Pit Pond Alternative

IV.1.6.a Visual Resources

The visual impacts of this alternative would be the same as those described for the Proposed Action.

IV.1.6.b Noise

The noise impacts of this alternative would be the same as those described for the Proposed Action.

IV.1.7 Partial Backfill Alternative

IV.1.7.a Visual Resources

The visual impacts of this alternative would be the same as those described for the Proposed Action during mine operation, but would be less following reclamation. Backfilling the pit to a daylight level and reclaiming the upper pit slopes would partially restore the former contours in the pit area and would decrease the contrasting forms, lines, and colors of the pit terraces and highwall visible from KOP 2. In addition, hauling waste rock material from the East Waste Rock Dump to backfill the pit would reduce the area covered by the dump by 82 acres and reduce the height of some of the benches in the dump. Hauling waste rock material from the West Waste Rock Dump to backfill the pit would reduce the height of the dump, slightly reducing the contrasts remaining following reclamation; however, the disturbance area would not be reduced. Portions of the pit highwall and the structures of the waste rock dumps would still be visible following reclamation, but the overall contrasts visible from KOPs 1 and 2 would be less under this alternative than under the Proposed Action.

IV.1.7.b Noise

The noise impacts of this alternative would be the same as those described for the Proposed Action during the operation period of the mine. The noise impacts would be greater during the reclamation period due to dumping, hauling, and regrading activities associated with backfilling the pit.

IV.J SOCIAL AND ECONOMIC RESOURCES

IV.J.1 No Action Alternative

The No Action Alternative will generate adverse social and economic impacts in the form of lost employment, personal income, tax revenue, and other economic benefits contributed by GSM. Under this alternative, all mining activity will cease in 1997 or 1998, causing an abrupt loss of the current 205 mining jobs provided by GSM. In 1994, the 257 mining jobs provided by GSM comprised nearly half of the mining employment and approximately 12 percent of the total covered employment in Jefferson County. Current percentage contributions provided by GSM are estimated to be slightly less. These will be discontinued under the No Action Alternative.

Mining sector employment contributes significantly to the local economy as it provides the highest wages of any employment sector in the state or county. Jefferson County mining sector wages were more than double the average state wage for all industries in 1994. Average wages in the mining sector in 1994 were $41,694 for Jefferson County. The average wage for all industries in Montana was $20,222. In 1993 GSM paid $11,259,255 in gross payroll, which is estimated to be 21 percent of the total wages and salaries earned in Jefferson County for that year. Current contributions are similar. These income contributions and their multiplier effects in the local economies will be lost under the No Action Alternative.

The loss of GSM's 205 jobs under this alternative will decrease county mining employment by nearly 40 percent and could cause a temporary increase in unemployment of up to 4.7 percent. (By comparison, a gradual phasing out of employment, as under the Proposed Action, would minimize some of the impacts of sudden mine closure by allowing a gradual adjustment period.) Upon mine closure, workers will likely attempt to acquire work at other mines or other businesses in the area, depending on the available jobs at that time. They are unlikely to leave the area and relocate, because most were hired by GSM from local communities. However, a lack of available employment may force many to relocate. Others will remain in the area, continuing their demands on community services and potentially increasing the demand on assistance programs.

The community of Whitehall will experience the most severe impacts from early closure of the mine. Currently 10 percent of the town's population is employed at the mine. Including family members, approximately 30 percent of the population is estimated to be dependent on GSM employment. In addition, mining jobs support secondary employment in the services sector and other industries. The mine contributes substantially to the core structure of the local economy. The community will experience adverse social and economic impacts on many levels from early mine closure.

Mine closure in 1997 or 1998 will cause a loss of tax revenues for the state and county. In 1995, GSM paid $318,557 in metals mine license tax, $238,730 in gross proceeds tax, and $672,092 in other property taxes, for total tax contributions of $1,229,379. GSM is estimated to have similar contributions for 1996. At the county level, GSM's most important contribution is through the property tax. Property taxes are a critical source of county revenue in Montana because there is no general state sales tax and no local-option income tax. And in rural counties, such as Jefferson County, with limited tax bases, large operations such as GSM can provide a substantial portion of the county's taxable value. In 1995, GSM provided 13.1 percent ($21,405) of the property tax revenues for the county general fund, 77.2 percent ($33,729) for Cardwell Elementary, and 39.3 percent ($129,394) for Whitehall High School. With mine closure, these property tax contributions will be lost. At the same time, budget revenue needs for the county and schools will remain essentially the same. No decreases or only slight decreases in student enrollment are anticipated, as most workers are expected to remain in the area and seek other work.

GSM economic contributions in the form of purchases of goods and services also will be discontinued under the No Action Alternative. From 1991 to 1994, GSM purchases in the state of Montana averaged $18,442,800 per year. Purchases add direct and induced income benefits to the economy.

Golden Sunlight Mine is an important component of the economic base in Jefferson County. Mine closure under the No Action Alternative will induce many adverse social and economic impacts through lost employment, income, tax revenue, and other contributions. County and school budget deficits may occur. The county is currently undertaking economic development activities and working to diversify the economy. However, mine closure in 1997 or 1998 will allow only a short time frame for planning and development of other sources of funding. School budget deficits will be partially offset by resources from the Hard Rock Mine Trust Reserve Account (described in Chapter III, Section III.J.5). However, the fund accrues over time, and substantially less funding will be available with mine closure in 1997 or 1998 than with mine closure in 2006, as under the Proposed Action.

Additional impacts under the No Action Alternative include the loss of anticipated future economic benefits. These are described in Section IV.J.2, Proposed Action Alternative below.

IV.J.2 Proposed Action Alternative

The Proposed Action would provide for continued mine operations through the year 2006. No increases in the current work force would be required. In the case of most mining projects, discussion of social and economic impacts centers around the changes in employment and population, and the associated impacts on housing, community services, and public finance. In the case of the Proposed Action, the primary impacts are the continuation of economic contributions and the effects of eventual mine closure.

Given that the Golden Sunlight Mine is an on-going operation and no new work force would be expected, no changes induced by the project are anticipated with respect to population, housing, schools, water supply, wastewater treatment, solid waste disposal, fire protection, law enforcement, health care, or community recreation. Continued operation of the mine would provide for on-going employment of mine personnel, the associated community benefits of high-wage mining sector employment and income, tax revenues for the state and county, and the economic benefits of local purchases of goods and services. A series of layoffs would begin in 2002 and end in 2005, after which time a minimal staff would be maintained for reclamation. Upon mine closure, at the end of mine life in 2006, tax revenues and other economic benefits provided by GSM would be discontinued.

As required by Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, the Proposed Action was evaluated for issues relating to the social, cultural, and economic well-being, and health of minorities and low income groups. Such issues are termed environmental justice issues, and none were identified for the Golden Sunlight Mine Project. Social and economic impacts of the Proposed Action would not affect minority or low income groups disproportionately.

IV.J.2.a Mine Development/Operation

Impacts associated with mine operation under the Proposed Action would be the continued economic benefits of employment and income provided by the mine, contributions to county and state tax revenues throughout the mine's projected 10-year life span (1997 to 2006) and purchases of goods and services in the local economy. Past economic contributions of the Golden Sunlight Mine are shown in Chapter III, Table III-17. Estimated future economic contributions through mine life to the year 2011, including a post-closure reclamation period, are shown in Table IV-16. These estimates are based on the projected employment listed below. Current employment is 205.

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Table IV-16

Projected Economic Contributions of Golden Sunlight Mine (1997-2011)

Item	Amount
Payroll:	
Salaries	$60,111,200
Payroll Taxes	4,872,000
Benefits	11,038,850
Total Payroll:	**$76,022,050**
Taxes:	
Property Tax	$5,452,400
Gross Proceeds Tax	4,181,000
Metals Mine License Tax	8,920,000
State Income Tax	2,970,000
Total Taxes:	**$21,523,400**
Purchases of Goods and Services:	
In Montana	$246,293,988
Outside Montana	140,222,291
Total Purchases:	**$386,516,279**
Total	**$484,061,729**

Source: Bartlett 1996.

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Years	Employment
1997	208
1998-2000	212
2001-2002	193
2003	100
2004	50
2005-2011	10

On-going employment at the mine would continue to provide substantial portions of county and local employment. Current GSM employment provides approximately 40 percent of the mining sector employment and approximately 9 percent of total covered employment in Jefferson County. Similar percentages would be provided by GSM employment through the year 2002, after which time employment would be phased out for reclamation.

The economic benefits of the high wages provided by mining sector jobs at the Golden Sunlight Mine would continue under the Proposed Action. In 1993, the annual gross payroll at GSM of $11,259,255 provided approximately 21 percent of the total wages and salaries earned in Jefferson County. With the reduced work force implemented in August 1996, payroll contributions are smaller, but they still provide an estimated 15 to 18 percent of county wages and salaries. Similar percentages would be provided by GSM payroll through the year 2002, followed by incremental decreases through the end of mine life as employment is phased out. Projected payroll (including salaries, benefits, and payroll taxes) through the life of the mine is estimated at $76,022,050 (see Table IV-16). Total annual salaries that GSM would provide are estimated at $8,622,848 for 1997, $8,788,672 for the years 1998 to 2000, $8,001,008 for the years 2001 to 2002, $4,145,600 for 2003, $2,072,800 for 2004, and $414,560 for the years 2005 to 2011. Additional benefits would be created as disposable income cycles through the economy, producing direct and induced income effects.

Under the Proposed Action, GSM would continue its contributions to state and county taxes. The mine currently provides substantial contributions to state and county tax revenues. In 1994, GSM paid $702,719 in metals mine license tax, $295,376 in gross proceeds tax, and $637,211 in other property taxes. The total tax payment was $1,635,306. Through the life of the mine, GSM estimates total tax payments of $21,523,400 (including state income tax), or $1,434,893 per year (see Table IV-16).

As described in Section IV.J.1, The No Action Alternative, property taxes are an important revenue source for the county. GSM provides substantial contributions to property tax revenues for Jefferson County and the local schools. GSM contributions in 1995 provided 13.1 percent ($21,405) of property tax revenues for the county general fund, 77.2 percent ($33,729) for Cardwell Elementary, and 39.3 percent ($129,394) for Whitehall High School. Percentage contributions were 4 to 8 percent higher in 1994. On-going contributions under the Proposed Action are expected to be comparable.

Economic contributions in the form of GSM purchases of goods and services would continue under the Proposed Action. From 1991 through 1994, purchases within the state of Montana averaged $18,442,880 per year. GSM purchases in Montana through the life of the mine are estimated at $246,293,988, or $16,419,599 per year (see Table IV-16). Direct and induced benefits in the economy would result from these purchases.

IV.J.2.b Mine Closure/Reclamation

The social and economic impacts from closure and reclamation of the Proposed Action would be the phasing out of employment at the mine and the loss of tax payments and other economic contributions provided by the mine.

Employment at the mine would be phased down from an average of 212 in the years 1998 to 2000, to 193 in the years 2001 to 2002, 100 in 2003, 50 in 2004, and 10 in the years 2005 to 2011. The most substantial layoffs would occur in the years 2002 to 2004. The phasing out of employment would partially facilitate a smoother transition for those affected by the job loss, as workers would be released back into the job market over a period of time, rather than all workers at once competing for available jobs.

GSM currently does not have a specific plan to aid affected workers in the transition process, but is presently holding discussions to address the issue and anticipates having a developed plan within a few years (Bartlett 1996). The GSM work force is a highly skilled and trained work force. Potential options include transferring to another Placer Dome operation, if opportunities are available at the time of lay-off; transferring to another mining operation within the area or out of state; or retraining to work in another industry.

Most GSM workers have been hired from the local area and therefore it is assumed that they would be unlikely to want to relocate upon mine closure. If transfer or retraining opportunities are not available at the time of job loss, the result may be a temporary rise in unemployment in the area. The community of Whitehall, in particular, would be impacted by the job loss because of the large percentage of its population employed at the mine. However, workers are cognizant of the fact that the mine has a finite lifetime, and they have the ability to plan for the anticipated loss of employment. Some workers are already investing in farms or side-businesses and exploring other income options (Bartlett 1996). Because the planning period is very long (from 4 to 7 years before significant job loss begins), the unemployment effects should be minimized. It is likely that a permanent employment shift would occur in the county from the mining sector to other sectors if unemployment and re-employment in other industries are the main results of mine closure. This would cause an accompanying decrease in county income, as mining sector employment provides the highest wages of any sector in the county.

Mine closure would result in decreases in tax revenues for the state and county. The state would lose revenue provided by GSM in the form of the metals mine license tax, gross proceeds tax, other property taxes, and income and payroll taxes. The taxable value in Jefferson County would decrease substantially, and the county would lose revenue in the form of the gross proceeds tax and property tax. Taxes currently provide approximately 50 percent of county revenues; property tax is the primary tax revenue source for the county. In 1994 and 1995, GSM contributed approximately 15 percent of the county general fund through property tax payments (shown in Chapter III, Table III-18). The percentage that GSM contributes by the end of mine life would depend on any changes that might occur in county funding patterns. However, GSM is likely to continue to provide important contributions, which would be discontinued with mine closure.

GSM's contributions to school revenue would be lost. Mine closure is not expected to reduce enrollments in the districts, since the mine hires primarily from local communities and workers are likely to remain in the area upon closure. However, mine closure would cause a large decrease in taxable value for the district and hence reduce school funding (Berenger 1996). In 1995, GSM provided 77.2 percent of the property tax revenues for Cardwell School and 39.3 percent for Whitehall High School. The percentages lost at the time of closure of the mine would depend upon future school district funding patterns. The impact may not be as great if school districts explore other funding options and appropriately plan for mine closure. The Hard Rock Mine Trust Reserve Account is expected to provide support for a number of years as the schools make the transition to other sources of funding. One third of the account is allocated for the elementary school district and one-third for the high school district. The account is activated when either GSM permanently ceases all mining-related activity, or the full-time work force is reduced to less than half of the average of the immediately preceding 5 years. In 1995, Jefferson County's trust reserve account held $3,603,414; this amount will be distributed between three districts, one of which is the Golden Sunlight district. The final amount that would be available to schools when the trust account is opened would depend upon the amount of tax levied from the metals mine license tax and the number of years accrued.

Other economic effects of mine closure include the loss of the mine's contributions to the local economy in the form of purchases of goods and services and the multiplier effects of income in the local economy from direct wages earned. GSM currently provides an important base for the local economy in the Whitehall area and contributes significantly to the county economy. The full value of the losses resulting from the closure of Golden Sunlight Mine are difficult to measure. Core dependence on one industry always incurs significant risks for an economy, especially when that industry's existence is very susceptible to changing market forces. Jefferson County recognizes these risks and is currently expending resources toward a number of economic development activities aimed at diversifying and strengthening the economic base. Impacts of mine closure may be reduced, depending upon the success of these activities (see Chapter III, Section III.J.5, Hard Rock Mine Trust Reserve Account, for more details of these activities).

IV.J.3 Return Diversion Alternative

The social and economic impacts of this alternative would be the same as those described for the Proposed Action.

IV.J.4 Divided Dump Alternative

The social and economic impacts of this alternative would be the same as those described for the Proposed Action.

IV.J.5 3:1 Slope Alternative

The social and economic impacts of this alternative would be the same as those described for the Proposed Action.

IV.J.6 No Pit Pond Alternative

The social and economic impacts of this alternative would be the same as those described for the Proposed Action.

IV.J.7 Partial Backfill Alternative

The social and economic impacts of this alternative would be the same as those described for the Proposed Action during mine operation. Additional work force would be maintained through the reclamation period for backfilling activities (for an estimated 14 to 44 years, depending on the utilization of labor and equipment), resulting in increased income earned.

IV.K HAZARDOUS MATERIALS AND WASTES

IV.K.1 No Action Alternative

The No Action Alternative requires that mining ceases when the waste rock dump space provided for in the *Interim Dump Plan* is filled. Under this alternative there will be no change in the baseline mining operations, facilities, or processes. The impacts associated with this alternative represent a continuation of hazardous material and waste management practices currently in use at the mine. These practices are discussed fully in Section II.B.1.a, Current Mining Operations, and briefly reviewed here.

All hazardous materials and wastes are transported to and from the site by DOT and EPA registered and approved transporters. All materials are shipped in recommended and approved containers and accompanied by the appropriate safety and emergency response documentation. There is no on-site disposal of wastes classified as hazardous or on-site storage of such wastes for more than 90 days. The facility maintains all hazardous material storage areas and tanks in compliance with its approved Stormwater Pollution Prevention Plan (SPPP). This plan requires that all storage tanks have secondary containment berms that hold a minimum of 110 percent of the volume of the largest tank in the bermed area. GSM uses secondary containment as the primary tool to prevent accidental release of hazardous materials to the environment. In addition, the mill complex and mine support facilities, where the majority of the hazardous materials are loaded/unloaded and used, are hydrologically separated from the surrounding environment such that all runoff ultimately drains to either Tailings Impoundment No. 1 or Tailings Impoundment No. 2. These two measures greatly reduce the chance that a release of hazardous materials will have any significant impacts to the environment.

In addition to the SPPP, the facility maintains a comprehensive emergency response plan that addresses environmental protection as well as employee safety. The plan, which is updated regularly to include any changes to the facility or process, provides all emergency notification telephone numbers; material safety data sheets for all hazardous materials on site; and the procedures for safety, handling, and cleanup of materials. The notification procedures outlined in the emergency response plan are as follows:

- Spills to surface water will be reported immediately to the local Disaster and Emergency Coordinator;
- Spills to the ground (greater than 25 gallons) will be reported as soon as possible; and
- Spills greater than the federally stipulated Reportable Quantity for that material will be reported to the federal government within 24 hours.

IV.K.2 Proposed Action Alternative

The Proposed Action Alternative would extend the life of the project and would not affect any of the baseline processes or activities at the site. Therefore, the additional potential impacts associated with this alternative only include those associated with the lengthening of the life of the project.

Under this alternative, mining operations would continue until approximately 2006, an increase of approximately 10 years. To analyze the impacts of this increase, the probability of a release of hazardous materials or wastes to the environment must be determined. Compliance with the requirements of the SPPP and the emergency response plan greatly reduce the chance of an accidental release of hazardous materials to the environment at the site. Transportation of hazardous materials and wastes to and from the site represent the greatest risk of release.

Process chemicals and waste materials could be accidentally released during transport to and from the site. Of these chemicals, diesel fuel, sodium cyanide, and liquid sulfur dioxide would represent more than 90 percent of the total mass of hazardous materials and hazardous waste shipped to and from the site. The

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average delivery rates of these chemicals are given in GSM's Operating Permit as 180 shipments of diesel fuel, 168 shipments of sodium cyanide, and 61 shipments of sulfur dioxide per year. Under the Proposed Action Alternative, the total number of shipments during the extended life of the project (10 years) would be 1,800 shipments of diesel fuel, 1,680 shipments of sodium cyanide, and 610 shipments of sulfur dioxide.

The majority of the project-related truck transport is assumed to be between Butte and the mine site. The probability of a truck accident resulting in the release of a hazardous material has been calculated using a national rate for such events as 0.28 release per million miles traveled (Abkowitz et al. 1984). Using this statistic, the release probability for the extended life of the project are as follows:

Diesel Fuel:

1,800 truck deliveries × 7 miles = total haul distance

total haul distance × 2.8 × 10^{-7} releases per mile = 0.0035 releases of diesel fuel in 10 years

Sodium Cyanide:

1,680 truck deliveries × 7 miles = total haul distance

total haul distance × 2.8 × 10^{-7} releases per mile = 0.0033 releases of sodium cyanide in 10 years

Sulfur Dioxide:

610 truck deliveries × 7 miles = total haul distance

total haul distance × 2.8 × 10^{-7} releases per mile = 0.0012 releases of sulfur dioxide in 10 years

The above analysis indicates that the probability of a release during the transport of any of the substances discussed above would be low. Considering that the transportation route investigated is primarily a rural, two-lane road, and that the probability is based on all types of roads, the actual probability of accidents may be slightly higher.

IV.K.3 Return Diversion Alternative

Impacts to hazardous materials and wastes would be the same as those described for the Proposed Action.

IV.K.4 Divided Dump Alternative

Impacts to hazardous materials and wastes would be the same as those described for the Proposed Action.

IV.K.5 3:1 Slope Alternative

Impacts to hazardous materials and wastes would be the same as those described for the Proposed Action.

IV.K.6 No Pit Pond Alternative

Impacts to hazardous materials and wastes would be the same as those described for the Proposed Action.

IV.K.7 Partial Backfill Alternative

Impacts to hazardous materials and wastes would be the same as those described for the Proposed Action.

IV.L CULTURAL RESOURCES

Discussions of project impacts are limited to sites that are located within the Area of Potential Effect (APE), or the area within the proposed project boundaries (as illustrated in Chapter II on Map II-1), and that are deemed to be significant or eligible for inclusion on the NRHP or that have federal and/or state protection under other statutes. Depending upon the alternatives chosen, up to eight eligible and unevaluated sites could be directly impacted by activities at the mine and up to eight eligible and unevaluated sites could be indirectly impacted. Table IV-17 and the following sections detail the anticipated impacts for each alternative.

Prior to the issuance of any license or permit or expenditure of any federal funds on the undertaking, a Section 106 consultation between the BLM (acting as lead agency for cultural resources) and the SHPO must be completed, as required under 36 CFR 800.3c. Section 106 consultation with the Montana SHPO regarding the project's effect on cultural resources is currently being conducted. The Section 106 process must be completed prior to the approval of the project (36 CFR 800.3c).

IV.L.1 No Action Alternative

Ground-disturbing activities associated with mine operations could result in direct impacts to prehistoric, proto-historic, and historic cultural resources in the form of vertical and horizontal displacement of soils containing cultural materials and in the loss of integrity of the cultural deposits, loss of information, and alteration of site setting. Additionally, mine activities could result in direct impacts to cultural resources by altering site settings and isolating the resource from access and further study. Alternatively, data recovery in affected sites adds to the information base for cultural resources within the area.

Increases in the number of people with access to the area, including GSM employees, could impact sites located outside of the direct impact area by making the sites more susceptible to vandalism and casual collecting. Subtle changes in topography due to mine construction and waste rock disposal also could result in indirect impacts to cultural resources due to alteration of the amount or patterns of erosion.

Avoidance of impacts through project redesign is the preferred method for protecting cultural resources. When disturbance of NRHP-eligible or other federal- and state-protected sites is unavoidable, impacts should be mitigated according to a site-specific treatment plan formulated in consultation among GSM, the BLM, the MDEQ, the SHPO, and the Advisory Council on Historic Preservation (ACHP), and any other identified interested parties (see Mitigation Measure C-1). This plan could include recording/documentation, education, collection, partial or complete excavation, and treatment or maintenance.

Under the No Action Alternative, a total of 3 sites will be directly impacted by mining activities, and 8 sites could potentially be indirectly impacted. Sites 24JF227, -228, and -229 have been previously impacted by activities occurring in the tailings impoundment areas under currently permitted operations (see Table IV-17). These three sites were determined ineligible by the BLM; no information on additional data recovery was identified. The SHPO has declined to comment since the sites have been destroyed by previous activities at the mine. The sites were located on private or patented land. Review of survey maps for the project area indicate that portions of the mine access road, the permanent water treatment plant, and the drainage area south of Tailings Impoundment No. 1 in the southern half of Section 32, T2N, R3W have not been surveyed for cultural resources (see Map III-7, Class III Cultural Resources Survey Boundaries). Impacts that have occurred to cultural resources in these areas associated with currently permitted operations cannot be determined without survey information. The Section 106 consultation with the SHPO conducted in 1996 and 1997 as part of the evaluation of effects from currently permitted operations concluded that completion of permitted mining activities would have *no effect* on NRHP-eligible or unevaluated properties

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Table IV-17

Disturbance Potentials for Known Eligible or Unevaluated Cultural Sites Located Within or Adjacent to the Proposed Project Boundary[1]

Site Number and NRHP Status	Existing Permitted Facilities	Proposed Action	Return Diversion Alternative	Divided Dump Alternative	2:1 Slope Alternative	Land Ownership
24JF227(JI)	D (previously disturbed)	D (previously disturbed)	D (previously disturbed)	D (previously disturbed)	D (previously disturbed)	GSM*
24JF228 (JI)	D (previously disturbed)	D (previously disturbed)	D (previously disturbed)	D (previously disturbed)	D (previously disturbed)	GSM*
24JF229 (JI)	D (previously disturbed)	D (previously disturbed)	D (previously disturbed)	D (previously disturbed)	D (previously disturbed)	GSM*
24JF292 (E)	I	I	I	I	I	GSM
24JF298 (NR)	–	–	–	D (area B1)	–	State*
24JF712 (E)	I	I	I	I	I	GSM
24JF717 (E)	I	I	I	I	I	BLM
24JF782 (JI)	I	I	I	I	I	GSM*
24JF942 (NEV)	I	D	D	D	D	GSM*
24JF944 (NEV)	I	D	D	D	D	GSM*
24JF1052 (E)	–	–	–	–	–	BLM
24JF1053 (E)	–	–	–	I (Area C2)	–	BLM
24JF1069 (E)	–	–	–	–	–	BLM
24JF1073 (E)	–	–	–	D (Area C1)	I	BLM
24JF1077 (E)	–	–	–	–	–	GSM
24JF1089 (E)	–	–	–	–	–	BLM

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Table IV-17 (Continued)

Site Number and NRHP Status	Existing Permitted Facilities	Proposed Action	Return Diversion Alternative	Divided Dump Alternative	3:1 Slope Alternative	Land Ownership
24JF1080 (E)	–	–	–	–	–	BLM
24JF1092 (E)	–	I	I	I	I	Private/GSM
24JF1095 (E)	I	D	D	D	D	Private/GSM
24JF1097 (E)	–	–	–	–	–	BLM
24JF1106 (E)	I	I	I	I	I	Private/BLM
24JF1123 (E)	–	–	–	I (Area C1)	–	BLM
Total Site Disturbance	3D 8I	6D 6I	6D 6I	Area A - 6D, 6I Area B1 - 7D, 6I Area B2 - 6D, 6I Area C1 - 7D, 7I Area C2 - 6D, 7I	6D 7I	

[a]Impacts identified under the No Pit Alternative and the Partial Backfill Alternative would be identical to those identified under the Proposed Action.

* = Needs final SHPO concurrence

– = No impacts anticipated

I = Indirectly impacted
D = Directly impacted
NR = None recorded
E = Eligible to the Register with SHPO concurrence
JI = Determined ineligible to the Register by the BLM pending SHPO concurrence
NEV = Additional data collection recommended

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(Wilmoth 1997a). As part of consultation on currently permitted operations, GSM agreed to reroute haul roads to avoid directly impacting sites 24JF942 and -944, and redesigned the waste rock dumps to avoid affecting sites 24JF292, -712, and -1106.

Sites with NRHP potential that are located in the area but are not expected to be directly impacted by currently permitted operations could still be indirectly impacted. These indirect impacts may include an increased potential for vandalism and illegal collecting, and potential effects from erosion or rock slides, particularly in those sites that are located directly adjacent to areas that will be disturbed through current operations. NRHP-eligible or unevaluated sites that may be indirectly impacted under the No Action Alternative include 24JF292 (Sheep Rock site), 24JF712, -717, -762, -942, -944, -1095, and -1106 (see Table IV-17). Based on consultation with the SHPO, and the level of previous disturbance in the vicinity of sites 24JF942 and -944, the potential for new indirect effects to these sites is expected to be slight (Wilmoth 1997a). Mitigation Measure C-2 addresses indirect impacts.

IV.L.2 Proposed Action Alternative

Direct and indirect impacts to cultural resources under the Proposed Action would be similar to those discussed under Section IV.L.1, No Action Alternative, except that additional sites could be affected.

At least three additional unevaluated sites or sites eligible to the NRHP (24JF942, -944, and -1095) could be directly impacted by the Proposed Action, for a total of six directly affected sites (see Table IV-17). The three additional directly impacted sites are located in the buttress expansion area (24JF942, -944), and to the east of the Tailings Impoundment No. 2 area (24JF1095); these 3 sites were identified as potentially indirectly affected under the No Action Alternative. If previously undocumented sites or subsurface components of documented sites are discovered within the existing permitted area, GSM has agreed, as part of their Proposed Action, to halt construction until the resources are examined by professional archaeologists (GSM 1995b). If the sites are eligible for the NRHP or protected under state and/or federal statutes, impacts should be avoided through project redesign. If avoidance is not possible, impacts should be mitigated through an appropriate data recovery program as determined through agency Section 106 consultation with the SHPO and the ACHP (see Mitigation Measure C-1).

Approximately six sites that are either unevaluated or eligible to the NRHP (see Table IV-17) that would not be directly impacted by the proposed disturbance could still experience indirect impacts associated with construction and operation of the project (sites 24JF292, -712, -717, -762, -1092, and -1106). These indirect impacts may include increased potential for vandalism and illegal collecting and potential effects from erosion, particularly in those sites such as 24JF292 and -1106, which are located directly adjacent to areas that would be disturbed by the project. Mitigation Measure C-2 addresses indirect impacts.

IV.L.3 Return Diversion Alternative

Impacts to cultural resources under the Return Diversion Alternative would be the same as those identified for the Proposed Action.

IV.L.4 Divided Dump Alternative

Impacts to cultural resources under the Divided Dump Alternative would vary, depending upon the waste rock disposal areas selected. The same sites identified for the Proposed Action Alternative would be affected under this alternative (direct impacts to sites 24JF227, -228, -229, 942, -944, and -1095, and potential indirect impacts to sites 24JF292, -712, -717, -762, -1092, and -1106), with additional impacts to cultural sites occurring for specific areas identified below. The total number of sites affected would include the 6 sites directly affected and 6 sites potentially indirectly affected, as identified for the Proposed Action, plus any additional affected sites associated with the waste rock disposal areas selected.

Area A: None.

Area B1: Site 24JF298 would be directly impacted. An eligibility ranking for site 24JF298 has not been made; it has been assumed that this site could be potentially eligible to the NRHP pending SHPO concurrence. The BLM is recommending that this site not be considered eligible for the NRHP; however, concurrence from the SHPO is still pending.

Area B2: None.

Land Bridge: None.

Area C1: Site 24JF1073 could be directly impacted and site 24JF1123 could be indirectly impacted. Both of these sites are protected under a patent covenant that restricts disturbance in the area. Any violation of the covenant could result in legal action. In addition, the portions of Area C1 and its associated buffer area that lie in Section 36, T2N, R4W, have not been surveyed to Class III standards. Impacts to potential sites in this area of Section 36 are unknown. Disturbance in this area prior to surveying could result in the loss of previously unidentified significant sites. Prior to any disturbance and issuance of the ROD, this area must be surveyed to Class III standards and any sites identified as eligible or potentially eligible to the NRHP would need to be avoided or mitigated under a treatment plan approved by the BLM, the state, the SHPO, and the ACHP (see Mitigation Measure C-3).

C1 Haul Road: None

Area C2: Site 24JF1063 could be indirectly impacted. This site is also protected under the patent covenant, and disturbance could result in legal action.

IV.L.5 3:1 Slope Alternative

Impacts to cultural resources under the 3:1 Slope Alternative would be the same as those identified for the Proposed Action, with the addition of potential indirect effects to site 24JF1073. This site is a patent-protected cultural property; any disturbance to the site could result in legal action.

IV.L.6 No Pit Pond Alternative

Impacts to cultural resources under the No Pit Pond Alternative would be the same as those identified for the Proposed Action.

IV.L.7 Partial Backfill Alternative

Impacts to cultural resources under the Partial Backfill Alternative would be the same as those identified for the Proposed Action.

IV.M NATIVE AMERICAN CONCERNS

IV.M.1 No Action Alternative

No comments from Native American Tribal groups notified by the BLM via the Quarterly Project List have been received regarding currently permitted operations. No traditional use or religious sites have been identified within the existing project permit boundaries. Following consultation with Native Americans on sites 24JF942, -944, and -296 in July 1997, the BLM recommended that these sites not be considered for listing in the NRHP. BLM is waiting for final agreement from tribal representatives before presenting the findings to the SHPO for concurrence. None of the talus pit sites protected under a patent covenant (24JF1062, -1063, -1073, -1089, -1090, -1097, -1123) in Section 25, T2N, R4W will be directly or indirectly affected under the No Action Alternative.

IV.M.2 Proposed Action Alternative

Impacts under this alternative would be the same as those described for the No Action Alternative. No impacts to cultural properties of significance to Native Americans would be expected to occur under the Proposed Action. No comments from Native American Tribal groups have been received to date on the Proposed Action Alternative operations.

IV.M.3 Return Diversion Alternative

Impacts to cultural properties of significance to Native Americans under this alternative would be the same as those identified for the Proposed Action.

IV.M.4 Divided Dump Alternative

Impacts to sites with significant importance to Native Americans under this alternative would be the same as those described for the Proposed Action, with additional impacts depending upon the waste rock disposal areas selected. No additional impacts would occur for Area A, Area B1, Area B2, the land bridge, or the C1 Haul Road. With selection of Area C1, direct impacts to talus pit site 24JF1073, and indirect effects to talus pit site 24JF1123 could occur; these sites are protected under patent covenant. If Area C2 is selected, indirect effects to talus pit site 24JF1063, another patent-protected site could occur. Under the patent covenant, disturbance to the sites is restricted. Any alteration to the sites as a result of mine activities could result in legal action. In addition, the portions of Area C1 and its associated buffer area that lie in Section 36, T2N, R4W, have not been surveyed to Class III cultural resource standards. Impacts to potential sites of significance to Native Americans in this portion of Section 36 are unknown. Prior to any disturbance, this area should be surveyed to Class III standards. If any sites are located, local tribal representatives should be consulted regarding the sites' significance, if any, to Native Americans (see Mitigation Measure NA-1).

IV.M.5 3:1 Slope Alternative

Impacts under this alternative would be the same as those identified for the Proposed Action, with the addition of potential indirect effects to site 24JF1073, a site protected under a patent covenant. Any disturbance to the site from mine operations could result in legal action.

IV.M.6 No Pit Pond Alternative

Impacts to cultural properties of significance to Native Americans under this alternative would be the same as those identified for the Proposed Action.

IV.M.7 Partial Backfill Alternative

Impacts to cultural properties of significance to Native Americans under this alternative would be the same as those identified for the Proposed Action.

IV.N REGULATORY RESTRICTIONS ANALYSIS

In 1995, the Montana Legislature amended MEPA to require Montana state agencies to evaluate in their MEPA documents any regulatory restrictions proposed to be imposed on the use of private property (MCA § 75-1-201[1][b][iv][D]). This section was included in order to satisfy the requirements of this new law.

The Proposed Action evaluated in this EIS would allow GSM to continue mining on lands owned privately by GSM, as well as on public lands owned by the United States and the state of Montana. Seven alternatives to GSM's Proposed Action and numerous mitigation measures have been developed as part of this EIS. These alternatives and mitigation measures would alter the way mining is conducted on private and public lands at the mine site in order to protect environmental and cultural resources. Thus, GSM's ability to profitably mine privately owned land would vary under the different alternatives and mitigation measures. The following sections provide a comparison of the costs associated with each alternative to the Proposed Action. The costs cited are those in addition to the costs of the Proposed Action.

Federal and state laws that regulate GSM's activities at the mine site include:

- National Environmental Policy Act;
- Clean Air Act;
- Clean Water Act;
- Resource Conservation and Recovery Act;
- Federal Land Policy and Management Act;
- Endangered Species Act;
- Migratory Bird Treaty Act;
- Antiquities Act;
- National Historic Preservation Act;
- American Indian Religious Freedom Act;
- Archaeological Resources Protection Act;
- Native American Graves Protection and Repatriation Act;
- Montana Environmental Policy Act;
- Montana Metal Mine Reclamation Act;
- Montana Air Quality Act;
- Montana Water Quality Act; and
- Montana Hazardous Waste and Underground Storage Tank Act.

Alternatives and mitigation measures designed to make the project meet minimum environmental standards with implementation methods specifically required by federal or state laws and regulations are excluded from evaluation under the Implementing Guidelines for MCA § 75-1-201(1)(b)(iv)(D). Alternatives and mitigation measures that are court mandated (measures that were specifically designated by the Montana First Judicial Court Order and Settlement Agreement dated February 7, 1995) also are excluded; these measures are a result of court interpretation of the minimum environmental standard of existing federal and state statutes.

Alternatives and mitigation measures that are evaluated for regulatory restrictions include those with potential alternate methods that could be used to satisfy federal and state regulatory requirements. In these cases, the benefits and costs, as they relate to the use of private property, are compared. The alternatives and mitigation measures evaluated do not necessarily prohibit further development of the mine site, but would require GSM to spend additional funds beyond the minimum required for compliance with environmental regulations. The more costs associated with regulatory compliance, the less economic benefit can be gained from the use of the property, and the more restrictive the regulatory action is to the use of private property.

IV.N.1 No Action Alternative

The No Action Alternative would constitute a regulatory decision based on the overall impacts of the project on environmental resources. The benefits of this alternative would be the elimination of environmental impacts caused by continued mining, and more rapid reclamation of existing disturbances. The costs include a substantial decrease in GSM's property value, and an almost total loss of anticipated future economic benefits. This alternative is extremely restrictive of GSM's use of private property even though it would eliminate many impacts. Several alternatives exist, with measures to reduce those impacts, including the Proposed Action.

IV.N.2 Proposed Action Alternative

Applicant Proposed Action.

IV.N.3 Return Diversion Alternative

The diversion of Sheep Rock Creek would prevent surface flows in the drainage from contacting acid producing waste rock materials in the East Waste Rock Dump area. The method described in the Proposed Action would divert flows from the Sheep Rock Creek drainage northeast into Conrow Creek. The method described in the Return Diversion Alternative would divert Sheep Rock Creek flows around the East Waste Rock Dump and reconnect with the natural drainage on the south side of the dump. The benefits of this alternative are the same as those for the diversion described in the Proposed Action, with the added benefits of preventing potential negative impacts to Conrow Creek from increased discharge volumes. The cost of the Return Diversion Alternative is estimated at approximately $372,800, whereas the cost of the Proposed Action measure is estimated at approximately $226,500. The Return Diversion Alternative would cost an estimated $146,300 more than the Proposed Action. The Proposed Action measure is less restrictive of the use of private property, but would not yield the increased benefits of the Return Diversion Alternative in preventing impacts to Conrow Creek.

IV.N.4 Divided Dump Alternative

This alternative provides alternate locations for waste rock disposal to prevent the contact of surface water in Sheep Rock Creek with acid-producing waste rock materials in the East Waste Rock Dump area. Under the Proposed Action, the East Waste Rock Dump facility would expand, and Sheep Rock Creek would be permanently diverted into the Conrow Creek drainage to prevent the contact of materials. Under the Divided Dump Alternative, the East Waste Rock Dump would not expand, and several other areas would be selected from to provide waste rock disposal capacity (see Chapter II, Map II-3). Waste rock dump areas provided on the west side of the mine would eliminate the problem of contact of materials in Sheep Rock Creek. If areas on the east side of the mine are selected, contact would be avoided by construction of a temporary land bridge across Sheep Rock Creek to access waste rock disposal areas east of the creek. A culvert would be constructed to allow the creek to flow underneath the land bridge. At mine closure, the land bridge would be removed and the creek would be allowed to flow in its natural channel.

Both the Proposed Action and the Divided Dump Alternative would prevent Sheep Rock Creek flows from contacting acid-generating waste rock. The Divided Dump Alternative provides the additional benefits of maintaining the integrity of the Sheep Rock Creek drainage channel, and eliminating the need for long-term maintenance of a permanent diversion structure. The additional direct and indirect costs associated with specific components of the Divided Dump Alternative are listed in Table IV-18.

Estimates available for the additional direct costs total $1,275,000 for Area A; $8,000,000 for Area B2; $10,000,000 for Area B1; $6,400,000 for the land bridge; $4,200,000 for Area C1; and $18,368,000 for Area C2. The total additional costs would vary with the areas selected. For the minimum disturbance scenario (Area C2), the total additional direct costs would be $18,368,000. For the maximum scenario (Area A, B2, and the land bridge) total costs would be $15,675,000. Estimates were not available for many direct costs, including increased capital costs to support longer hauls, and the costs of constructing a new pit access road and new haul road to the West Waste Rock Dump area. Other costs include nonquantifiable costs and indirect costs such as dumping delays, increased land disturbance, and aesthetic effects of the new haul road. The

Table IV-18

Direct and Indirect Costs of the Divided Dump Alternative

Area	Description of Cost	Amount
Area A	Relocating 550,000 cubic yards of topsoil	$1,000,000
	Construction and operation of a new pit access road:	
	- disturbance of land already reclaimed	b
	- construction of new road	a
	- increased hauling costs due to uphill grade	$275,000
Area B2	Increased hauling costs due to longer hauling distance	$8,000,000
	Increased capital costs for purchase of additional equipment	a
	Dumping delays (approximately 3 to 4 months) due to time frame for soil stripping	b
Area B1	Increased hauling costs due to longer hauling distance	$10,000,000
	Increased capital costs for purchase of additional equipment	a
	Increased land disturbance (land in Section 21 would be disturbed)	b
	Dumping delays due to time frame for soil stripping	b
Land Bridge	Construction of land bridge, including the culvert, pad, berms, compaction, road, dumping platforms, off-loading of material, and removing culvert	$6,400,000
	Increased hauling cycle times due to specific placement of waste material	b
	Dumping delays (approximately 3 to 4 months) due to time line of construction	b
	Ultimate disturbance of approximately 70 percent of the Sheep Rock Creek channel adjacent to the dumps	b
Area C1	Increased hauling costs	$4,200,000
	Increased capital costs for purchase of additional equipment needed to support longer hauls	a
C1 Haul Road	Haul road construction	a
	Comprehensive erosion control system to maintain road and hillside	a
	Aesthetic effects of large road cut and erosion on hillside	b
Area C2	Pit redesign to accommodate increased haul road width	
	- Decreased long-term profitability of the mine by reducing ore reserves in pit bottom	b
	- Delay of mining in the pit	b
	Increased hauling costs	$18,368,000
	Increased capital costs for additional equipment needed	a

Source: Foster and Noel 1996.

a = estimate not available.

b = non-quantifiable cost.

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direct and indirect costs of the Divided Dump Alternative are very large in comparison to the Proposed Action. This alternative would provide for much greater regulatory restriction on the use of private property than the Proposed Action.

IV.N.5 3:1 Slope Alternative

This alternative provides an alternate method of waste rock dump slope reclamation. Under the Proposed Action, waste rock dump slopes would be reclaimed at a combination of grades ranging from 2:1 to 3:1, depending on the location. Under the 3:1 Slope Alternative, additional slopes in the East and South and West Waste Rock Dumps would be graded to 3:1 prior to revegetation. The 3:1 Slope Alternative would address the concerns raised in the Court Order and Settlement Agreement regarding the feasibility of reclaiming 2:1 waste rock dump slopes. Utilizing 2:1 slopes would cause less surface disturbance than 3:1 slopes and would require less soil stripping and regrading. The total additional cost for reducing slopes under the 3:1 Slope Alternative is estimated at $13,263,400, including $12,000,000 for regrading, $1,200,000 for soil stripping, and $63,400 for vegetation. Other indirect costs also may result. This alternative would be more restrictive of the use of private property than the Proposed Action.

IV.N.6 No Pit Pond Alternative

This alternative describes an alternate method of pit reclamation. Under the Proposed Action, the pit would be allowed to partially fill with surface water and groundwater following the end of mining. Water would be pumped from the pond in the pit bottom to the permanent water treatment plant as needed to maintain the pit as a hydrologic sink, and to prevent poor quality groundwater from leaving the pit area. Under the No Pit Pond Alternative, no water would be allowed to pond in the pit bottom. Surface water and groundwater that enter the pit would be collected in a sump below ground and continually pumped to the permanent water treatment plant. The pit also would be partially backfilled to the 4,800-foot level (approximately 100 feet) in order to provide safe access to the floor of the pit for periodic maintenance of the dewatering system.

The dewatering system would cost an estimated $75,000 to $150,000, including costs for shallow wells, pumps, electronics, and pipelines. Potential pit dewatering outflow under the No Pit Pond Alternative is estimated to be up to 102 gpm, compared with 54 gpm under the Proposed Action. However, the same size water treatment plant would be constructed under both alternatives because the plant was originally designed to handle flows in excess of those estimated under the Proposed Action. The main difference in cost of the water treatment plant would be the operating costs, specifically the chemicals used in the treatment process. These costs cannot be estimated at this time because of uncertainties in effluent quality at mine closure. The additional costs of backfilling the pit under this alternative are approximately $296,000. Overall, the additional costs of the No Pit Pond Alternative would be approximately $371,000 to $446,000. This alternative would be more restrictive of the use of private property.

IV.N.7 Partial Backfill Alternative

This alternative describes an alternate method of pit reclamation. Under the Proposed Action, approximately 19 acres of pit benches would be capped with rock and soil and revegetated, and approximately 235 acres of the pit would not be revegetated. Under the Partial Backfill Alternative, all acid-producing rock within the pit (approximately 254 acres) would be capped with oxidized waste rock and soil, and revegetated. The pit would be backfilled to a daylight level, and the upper pit slopes would be reclaimed. Material to backfill the pit would be removed from the East and West Waste Rock Dumps. One of the primary benefits of this alternative would be the reduction in the amount of surface water recharge in the pit that potentially needs to be treated (by up to approximately 52 gpm) because stormwater could be routed directly off of the reclaimed-slopes out of the pit area. It also would, therefore, reduce the amount of dewatering required to maintain the pit as a hydrologic sink. Additionally, under this alternative, a greater portion of disturbed lands would be revegetated, and the size of the East and West Waste Rock Dumps would be reduced.

The costs of backfilling the pit and capping with oxide rock and topsoil are estimated at $32,500,000. Pit water pumping and treatment would cost about the same as the Proposed Action. Another disadvantage of this alternative is that partial backfilling of the pit would restrict or preclude the potential future mining of ore under or adjacent to the pit. Because of the extremely large costs associated with backfilling the pit, the Partial Backfill Alternative would be much more restrictive of the use of private property than the Proposed Action. The agencies conducted a separate evaluation to determine the economic feasibility of this alternative.

IV.O CUMULATIVE IMPACTS

Cumulative impacts are defined as the impacts that result from the incremental effect of an action, decision, or project when analyzed with respect to other past, present, and reasonably foreseeable future actions (RFFAs). For this analysis, actions or projects have been examined that are in the same general geographic area as the Golden Sunlight Mine and that have potential environmental impacts on the same resources as those impacted by the Proposed Action or alternatives. These projects consist of other mining operations, other potential large-scale employers, and exploration activity in the vicinity of the mine.

IV.O.1 Area and Time-Frame for Cumulative Analysis

The specific area of impacts analysis may be different for each resource. The Proposed Action is relatively distant from other mining operations or large-scale projects. This distance tends to limit the potential for cumulative impacts. These projects and resource disciplines occur both within and outside of Jefferson County. Because county-wide cumulative disturbance data are unavailable, cumulative acreage comparisons could not be made. Impacts analyzed from past actions were generally limited to past actions at the Golden Sunlight Mine. The analysis time period extends for the life of the mine, including development, operation, closure, and reclamation. Under the Proposed Action and other action alternatives, the mine would continue operating through the year 2008, with reclamation following closure at this time.

IV.O.2 Past, Present, and Reasonably Foreseeable Future Actions

Montana Tunnels

The Montana Tunnels operation is a gold mine located 45 to 65 miles north of the Golden Sunlight Mine, in central Jefferson County, between Jefferson City and Clancy. Facilities include a concentrating plant for processing materials. Current employment at the mine is 285, with closure scheduled in 1999. The potential exists for the nearby Diamond Hill Mine to utilize the concentrating plant for processing after closure of Montana Tunnels. If the concentrating plant continues operation, approximately half of the current employees will be laid off when the mine closes. If the plant does not continue operation, nearly all of the 285 employees will be laid off. It is not known at this time whether the Montana Tunnels operation will attempt to extend the life of the mine based on the location of other resources at the facility (Miller 1996). Potential impacts from the project would occur during closure, as unemployment in the region may be compounded by closure of Montana Tunnels coinciding with lay-offs at Golden Sunlight Mine. Cumulative impacts to tax revenue losses for the county also may occur.

Ash Grove Cement

This operation is another major employer and contributor to tax revenues in Jefferson County. No closure is anticipated for the operation at this time, however, and no cumulative impacts would result from this project.

Montana Resources

The Montana Resources copper-molybdenum mine is the closest active mining operation to the Golden Sunlight Mine. It is located in adjacent Silver Bow County near Butte, approximately 22 miles from the Golden Sunlight Mine. It currently employs approximately 320 workers, and has estimated ore reserves for approximately 35 years (Blodgett 1996). Potential cumulative impacts to regional mining employment would occur only if copper prices drop significantly to make mining the low grade ore economically unfeasible. No cumulative impacts to local government finance would be anticipated due to the mine's location in a different county. Cumulative impacts to other resources would not be anticipated due its distance from the Golden Sunlight Mine.

Continental Lime Mine and Processing Plant

This operation is located near Townsend, in adjacent Broadwater County, approximately 35 miles from the Golden Sunlight Mine. Due to its distance and location in a different county, no cumulative impacts would be anticipated from this project.

Basi Mountain

The Basi Mountain operation is a cyanide heap leach gold mine located at the western end of Silver Bow County, approximately 42 miles from the Golden Sunlight Mine. The mine employs approximately 70 workers, most of whom live in Anaconda and Butte (Blodgett 1996). Most of the recoverable ore reserves have been tapped out and closure is anticipated in 1997 or 1998. Closure of the operation could contribute slightly to cumulative unemployment impacts of the No Action Alternative, as the mine is located in the regional job market of the Golden Sunlight Mine. However, no cumulative impacts to local government finance would occur due to its location in a different county. Cumulative impacts to other resources are not anticipated because of the geographic separation of the two mines.

Exploration Activity at Golden Sunlight Mine

Mineral exploration activities within the permit boundary have been evaluated for cumulative impacts to the extent possible based on existing information. The results of the exploration activities, however, may identify viable ore bodies within the project area. Such ore bodies would likely be proposed for mining in the future. Since the results of the exploration program are not known at this time, the cumulative impacts of potential future mining activities cannot be estimated. Cumulative impacts of exploration activities were limited to analysis of current and proposed disturbances.

GSM's current Operating Permit for exploration includes the following activities (GSM 1995d):

- Geologic mapping;
- Geologic, geophysical and geochemical testing;
- Exploration, geophysical, and condemnation drilling;
- Groundwater monitor well drilling;
- Drilling to define suitable reclamation materials;
- Drilling to evaluate geotechnical stability;
- Installation of inclinometers;
- Excavation of geotechnical, geophysical, and exploration trenches and test pits; and
- Road construction for drilling and trenching.

The disturbance area for these activities includes approximately 236 acres out of the 8,250-acre exploration permit boundary. GSM is presently developing a geologic model to determine whether additional drilling or underground exploration is warranted in the pit area. However, there are no immediate plans to conduct such activity at this time.

IV.O.3 Past, Present, and Reasonably Foreseeable Future Impacts

IV.O.3.a Geology, Minerals, and Paleontology

There are no anticipated cumulative geotechnical impacts expected for the proposed project. Cumulative impacts to geologic and minerals resources in the project area would include those due to other mining operations or future proposed operations. No other types of activities in the region have been identified that would contribute to these cumulative impacts. The Golden Sunlight Mine is located relatively distant from other mining operations. The closest active mining operation is operated by Montana Resources, located near Butte, approximately 22 miles from the Golden Sunlight Mine. Continental Lime operates a mine and processing plant near Townsend, approximately 35 miles away. Due to the distance of other operations, no cumulative impacts are anticipated from Golden Sunlight Mine operations. No future mining beyond the Proposed Action is currently known or proposed.

Past and present activities in the cumulative effects area considered for paleontology, generally defined as the proposed expansion boundary, have directly and indirectly affected paleontological resources in the area. Past and present development of the tailings impoundment and buttress areas have limited access to and restricted study of potential fossil-bearing Tertiary deposits found in these areas. A significant paleontological site located on GSM land near Sheep Rock (site 24JF292) has been studied in detail over the past 6 years and contains unique macrofaunal remains of cheetah, camel, horse, and mountain sheep.

Future plans to develop borrow areas, quarries, and conduct additional exploration work within the proposed permit expansion boundaries could directly impact potential fossil-bearing formations in Sections 28, 21, and 29, and could lead to further access and study restrictions in these areas as well as additional indirect impacts. The discovery of significant paleontological resources could, however, also provides additional paleontological information if data recovery proceeds on directly impacted significant sites.

IV.O.3.b Water Resources

Cumulative impacts to water resources may occur in the area surrounding the Proposed Action if other projects that impact surface or groundwater resources are located within or near the drainage basins potentially impacted by the Proposed Action or other alternatives. In the vicinity of Golden Sunlight Mine, no other mines that would add impacts to water resources are currently identified. However, high pre-existing soil nitrogen levels coupled with fallow farming and irrigation practices immediately south of the mine site may have cummulative impacts to groundwater quality when combined with slightly elevated TDS and total cyanide levels from Tailings Impoundment No. 1 seepage.

IV.O.3.c Soils and Reclamation

Activities within the cumulative effects area which can be reasonably foreseen to occur include the exploration, geotechnical, and monitoring activities proposed by GSM in 1995. The total area proposed to be affected includes approximately 226 acres which would be cumulative to the acreage associated with the project alternative eventually selected for implementation. The soils overlying the 226 acres would be directly affected by planned exploration activities which include road construction, drilling, and trench excavation. Soil salvage would occur to a depth of 6 inches where possible. The remainder of the subsoils would be mixed to varying degrees during facility construction, with trench excavations likely having the most extensive impacts to subsoils. Soil compaction also would occur along roadbeds and within the boundaries of drill pads. Though subsoil mixing would occur, no subsoils would be buried since all facilities would be removed and disturbance areas revegetated following the end of exploration activities. The sole possible exceptions to this are constructed roads which would be required by the agencies to be left for access purposes. Soil erosion would occur but only to a minor extent given the construction activities planned, areal extent of disturbances, and the commitment to revegetate all disturbed areas. A short-term reduction in soil productivity would be experienced between the time of facility construction and revegetation.

IV.O.3.d Vegetation and Wetlands

The cumulative effects area for vegetation and wetlands includes the area within the proposed permit boundary and additional acres within the larger exploration area. The current permit boundary encompasses approximately 5,071 acres. Past and present disturbance areas include the pit, East and West Waste Rock Dumps, buttress, the combined tailings and borrow area, and other facilities (see Chapter II, Table II-1). These facilities have disturbed and removed vegetation on approximately 2,336 acres or 46 percent of the currently permitted area. The permit boundary under the Proposed Action Alternative would encompass an additional 1,054 acres to total 6,125 acres. The Proposed Action would disturb or remove an additional 627 acres of vegetation resulting from expansion of current facilities. The disturbance boundary for exploration activity encompasses 8,250 acres, including the 6,125 acres of the proposed mine permit boundary. The disturbance due to exploration within that area is projected to be approximately 226 acres.

A total of 3,200 acres of surface disturbance would result from past, present, and proposed mining activities, and other reasonably foreseeable future actions in the cumulative effects area. The loss of vegetation from activities through the *Interim Dump Plan* has resulted in the loss of livestock and wildlife forage, and protective cover for wildlife. The loss of mature trees and shrubs would be minimal relative to the total acreage of coniferous forest, Rocky Mountain juniper woodland, and shrub-dominated communities that occur in the cumulative effects area.

Past mining activities have resulted in the filling, excavation, or removal of 3.1 acres of non-wetland WUS and 0.08 acre of wetland WUS. The Proposed Action would disturb an additional 1.8 acres of non-wetland WUS (no wetland WUS would be filled or removed). Exploration activity is not expected to impact any additional WUS areas. Slightly to moderately reduced spring flows are anticipated through completion of currently permitted mine activities. Greater spring flow reductions would occur through implementation of the Proposed Action. None of the identified RFFA´s would further impact spring flows in the project area.

IV.O.3.e Wildlife and Fisheries Resources

Assessing cumulative impacts quantitatively for wildlife resources is difficult and contains inherent biases. Therefore, this analysis was based on overall qualitative values apparent in the cumulative impacts area. The cumulative effects area for wildlife and fisheries resources includes the area within the proposed permit boundary, adjacent terrain in the Bull Mountain area, and the surface water drainage systems into the Boulder and Jefferson Rivers. The current permit boundary encompasses approximately 5,071 acres, while the proposed permit boundary encompasses approximately 6,125 acres. Past and present disturbance areas within the permit boundary are discussed in the cumulative analysis sections for soils, vegetation, and land use. Potential future disturbance activities within the permit boundary are associated with GSM's exploration plan.

The primary cumulative impacts to wildlife resources would include displacement, incremental habitat loss and fragmentation, and a potential decrease in the overall carrying capacity for wildlife in the region until reclamation is complete. Increased development under future activities within the cumulative impacts area would result in continued habitat fragmentation and animal displacement into adjacent habitats. Direct loss of native vegetation would further limit viable habitat for area wildlife populations, which would result in decreased breeding, foraging, and cover potential. Reclamation of previously disturbed areas under the Proposed Action, other alternatives, and/or future actions would minimize long-term impacts to wildlife habitat in the mine vicinity. The reclaimed areas would still be capable of supporting wildlife use, but species composition and densities would change.

Overall cumulative impacts from the RFFA's would parallel those discussed for the Proposed Action. Urban expansion and development along the I-90 corridor, as well as road construction associated with mine exploration activities, would improve access to more remote areas, which would result in increased human presence and increased pressure on resident wildlife populations in the cumulative effects area. Certain resources are more susceptible to impacts than others, such as riparian zones, springs and seeps, seasonal ranges, movement corridors, and active breeding areas. The degree or level of anticipated cumulative impacts would depend upon the location of these natural resources and the duration of human disturbance. Effects from the Proposed Action and RFFA's would add to overall habitat fragmentation and animal displacement.

The cumulative effects to surface water sources are a critical issue in this analysis. As stated in the cumulative discussion for water resources, construction of the proposed water management system (i.e., diversion structures, retention berms, permanent water treatment plant, and monitoring wells) would be expected to maintain existing water quality levels through operation and reclamation of the Proposed Action or any of the alternatives. The potential cumulative effects to groundwater described in Section IV.O.3.b, Water Resources, could affect wildlife resources in the cumulative effects area if the lower quality groundwater were to adversely affect resources utilized by wildlife.

IV.O.3.f Threatened, Endangered, and Candidate Species

Cumulative impacts to sensitive species would be the same as those described for wildlife resources in Section IV.O.3.e.

IV.O.3.g Air Quality

Impacts to air quality from mining operations are primarily from particulate matter and tend to be localized in the vicinity of the source. The geographic extent of impacts is generally small; on the order of 8 to 10 kilometers (5 to 6 miles) from the mine permit boundary. Cumulative impacts to air quality include the existing Golden Sunlight Mine operations and fugitive dust sources, proposed emission sources from mining and ore processing operations, as well as impacts from other existing emission sources in the area (cattle grazing, unpaved roads, etc.). Exploration activity under GSM's existing operating plan for exploration also would contribute to particulate emissions through fugitive dust from ground disturbance for drilling, road construction, trenching, and other activities. Due to the small extent of anticipated disturbance (236 acres), these activities would contribute minimally to emissions in the area.

Cumulative impacts from existing operations are already reflected in the measured particulate levels at the site. The cumulative impacts from the Proposed Action, exploration, and other activities in the area are not considered significant. State and federal air quality standards would not be exceeded. Because the other identified RFFAs are not within the cumulative effects area for air quality (i.e., 8 to 10 kilometers), they would not contribute to cumulative impacts in the mine area.

IV.O.3.h Land Uses and Plans

For the purposes of land use, the cumulative impacts analysis applies only to other proposed and reasonably foreseeable future activities within the immediate mine vicinity. Cumulative impacts to land disturbance and grazing may occur as a result of on-going and proposed exploration activities. No other projects within the region have been identified that would contribute to cumulative impacts to land use.

The total maximum proposed permit area described in GSM's current Operating Permit for exploration encompasses 8,250 acres, including 5,071 acres of the current mine permit boundary. Exploration activities are segregated into four categories (Class I to IV) of drill density and trenching activity. Class I is defined as low density, and Class IV as high density. Most of the exploration activity is of Class 2 intensity. Table IV-19 shows the surface ownership and types of disturbance within the exploration permit boundary. Surface ownership of areas within the exploration permit boundary includes 3,735 acres of GSM land, 3,724 acres of BLM-administered land, 750 acres of state land, and 41 acres of other private land. Actual disturbance is estimated at 135 acres of GSM land, 90 acres of BLM-administered land, and 11 acres of state land, for a total of 236 acres, with no more than 100 acres unreclaimed at any one time.

State subsurface lands also would be affected by exploration activity in T2N, R3W, Sections 16, 17, 20, 21, 28, 33, and T2N, R4W, Section 36. However, exploration activities would not increase the amount of permanent disturbance or placement of structures over state subsurface lands, and therefore, would not limit access to the state mineral estate.

Exploration activities impact grazing areas through soil compaction and construction of roads and other facilities. The exploration permit boundary area encompasses an additional 2,305 acres of the Bull Mountain Allotment and 985 to 1,015 acres in the Hill and

Table IV-19

Surface Ownership and Types of Disturbance Within Exploration Permit Boundary Area

Land Owner/ Administrator	Area in Permit Boundary (Acres)	Number of Drill Sites	Trench Length (Feet)	Roads Length (Feet)
GSM	3,735	691	3,900	63,800
BLM	3,724	304	3,900	56,900
State	750	12	700	10,000
Other Private	41	0	0	0
TOTAL	8,250	1,007	8,500	130,700

Source: GSM 1995d

Table IV-20

Cumulative Disturbance Within Grazing Allotments (Acres)

Allotment	Total Area in Allotment	Disturbed Through the *Interim Dump Plan*	New Disturbance Under the Proposed Action	Estimated Potential New Disturbance From Exploration	Total Disturbance
Bull Mountain	5,410	205	0	70	275
Hill and Wilkerson	4,200	460	350-400	30	840-870

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Wilkerson Allotment beyond the current disturbance boundaries. Table IV-20 shows cumulative disturbance within the Bull Mountain and Hill and Wilkerson grazing allotments. Potential new disturbance from exploration is estimated at 70 acres in the Bull Mountain Allotment and 30 acres in the Hill and Wilkerson Allotment. This would cause a temporary loss of approximately 9 AUMs in the Bull Mountain Allotment, and would contribute to the temporary loss of early spring grazing pasture in the Hill and Wilkerson Allotment.

Exploration also would add slightly to the minimal anticipated impacts on dispersed recreation in the area (see Section IV.H.2, Proposed Action Alternative, of Land Uses and Plans). However, these impacts would not be significant.

Land use impacts of exploration activities are considered temporary. Reclamation is on-going during activity, and, upon completion of the program, all disturbed sites will be reclaimed within 2 years of the last disturbance created. No other cumulative land use impacts have been identified.

IV.O.3.i Aesthetic Resources

Visual Resources

No other projects have been identified that would contribute to cumulative visual impacts in the project area, with the exception of exploration activity at the mine, as described in the *Operating Permit for Exploration, Geotechnical, and Monitoring Activities by Golden Sunlight Mine, Inc.* (GSM 1995d). Construction of access roads for exploration activity would temporarily add contrasting horizontal and diagonal lines, lighter colors, smoother textures, and additional geometric forms to the landscape. Visual contrasts in the mine area would increase slightly. These contrasts would be reduced as roads are reclaimed following exploration. Other temporary visual disturbances created by drilling and other activities would be minimal.

Noise

No other projects have been identified that would contribute to cumulative noise impacts in the project area, with the exception of exploration activity at the mine. Noise would be generated by drilling and road construction for exploration. Noise levels in the mine area would be increased by these activities. However, impacts on sensitive noise receptors are expected to remain minimal.

IV.O.3.j Social and Economic Resources

Cumulative social and economic impacts would result from all proposed or envisioned actions that have the potential to affect population, community services and infrastructure, employment, the economy, and public finance. The study area for social and economic resources for most impacts is defined as Jefferson County but includes areas of other counties where they are part of the regional job market. Cumulative effects were identified for employment, economic, and public finance impacts.

Montana Tunnels, a gold mine located in central Jefferson County, is scheduled to close mining operations in 1999. Unemployment caused by closure of Montana Tunnels could potentially exacerbate unemployment caused by GSM scheduled lay-offs. Most current employees of Montana Tunnels reside in the communities of Jefferson City, Clancy, and Helena, 45 to 65 miles north of Whitehall and the Golden Sunlight Mine. Employees of the two operations are in the same regional job market. Currently, the total employment for the Montana Tunnels operation is 285 (Miller 1996). The potential exists for the concentrating plant to continue operations, if supply sources can be obtained from other mines. When mine operations cease, approximately half (143) of the employees will be laid off if the concentrating plant continues operation. If the plant does not continue operation, 250 to 285 employees are likely to be laid off.

Under the No Action Alternative, most of the approximately 205 GSM employees would be laid off in 1997 or 1998. If Montana Tunnels closes 2 years later, individuals laid off from this operation would potentially be competing with any former GSM employees who are still seeking work. Under the Proposed Action, 19 GSM employees would be laid off from 2000 to 2001; 93 from 2002 to 2003; 50 from 2003 to 2004; and 40 from 2004 to 2005. Employees laid off from Montana Tunnels in 1999 would potentially compete for jobs with GSM employees laid off starting in 1999, provided that transfers or other employment opportunities are not available for either GSM or Montana Tunnels personnel.

Public finance also would experience cumulative effects from closure of Montana Tunnels and the Golden Sunlight Mine. In 1994, GSM contributed $18,917, or 17.2 percent of the property tax revenues for the county general fund; Montana Tunnels contributed $21,460, or 19.5 percent. Under the No Action Alternative, the county would lose GSM's contribution in 1997 or 1998 and Montana Tunnels' contribution in 1999 - potentially 30 to 40 percent of its total revenues from property taxes. This could impose considerable fiscal constraints on county budgeting; the potential for budget deficits would increase. Under the Proposed Action, GSM contributions would decrease or discontinue at the end of the operations period in 2006, approximately 7 years following the Montana Tunnels closure. This is a relatively short period of time for a county to experience two major decreases in tax revenue. School districts for the two mines do not overlap, so there would be no cumulative effects on school funding (with the exception of decreases in property tax contributions to the state school equalization fund).

Additionally, cumulative impacts would occur in the local economy from the loss of income provided by high-wage mining sector jobs, support of secondary employment, the cycling of income through the economy, and purchases of goods and services by the mines. Permanent closure of the two mines could permanently alter the employment and economic base of the county.

Closure of the Beal Mountain operation, 42 miles away in Silver Bow county, could potentially contribute to regional unemployment effects of mine closure, as it is located within the general regional job market of the Golden Sunlight Mine. Closure is scheduled approximately within the next year. However, these impacts would be minimal because closure would occur several years before closure at Golden Sunlight Mine, and Beal Mountain does not employ a relatively large number of workers.

No other operations have been identified that would contribute to cumulative impacts in the study area.

IV.O.3.k Hazardous Materials and Wastes

As discussed in Section IV.K, Hazardous Materials and Wastes, there would be no significant cumulative impacts due to hazardous materials use and storage at the site.

IV.O.3.l Cultural Resources

The cumulative effects area for cultural resources has been defined as the area within and immediately adjacent to the permit boundary. The only RFFA identified within this area is exploration activity at the Golden Sunlight Mine.

Between 1980 and 1996, 13 cultural resource inventories were conducted in the vicinity of the Golden Sunlight Mine (see Chapter III, Table III-20 and Map III-7). These inventories identified 15 sites that are eligible to the NRHP (see Table IV-17). Seven unevaluated sites lie within or adjacent to the Proposed Permit boundary (24JF227, -228 -229, -298, -762, -942, and -944) (see Section III.L.3, Cultural Resources Identified in the Project Area). Sites 24JF227 to -229 are assumed to have been previously destroyed under activities conducted as part of currently permitted operations.

Nineteen sites eligible or potentially eligible to the NRHP that have not been directly impacted under past or present operations are located within the cumulative effects area for cultural resources. These include sites 24JF292, -296, -712, -717, -762, -942, -944, -1062, -1063, -1069, -1073, -1077, -1089, -1090, -1092, -1095, -1097, -1106, and -1123 (see Table IV-17). Future plans for mining-related projects such as borrow pits and quarries could potentially affect these sites. Also, inventories have not been completed for the entire cumulative effects area, including portions of Sections 32 and 36. It is not known how many, if any, cultural resources exist in these unsurveyed areas. According to state and federal requirements, these areas should be inventoried prior to the signing of the EIS's Record of Decision, and mitigated, as necessary, prior to any disturbance.

Additional cultural inventories that may be required for future exploration activity at the Golden Sunlight Mine would add to the information base for cultural resources within the cumulative effects area. Compliance with Sections 106 and 110 of the National Historic Preservation Act of 1966 would result in the evaluation and mitigation of any significant properties identified during inventories on public lands and also would add to the overall knowledge of cultural resources in the cumulative effects area. Even with mitigation, physical destruction of sites could still occur from exploration activity, and there would be permanent loss of some cultural sites. Permanent loss of sites also has occurred within the areas disturbed by past and present actions. Indirect impacts, such as vandalism and illegal collecting, have and could occur to cultural resources through continued or increased access and human presence as a result of exploration activity and past and present activities.

In addition to the 3 potentially eligible sites directly impacted during past and present operations at the mine (24JF227, -228, and -229), 3 additional eligible or potentially eligible sites would be directly impacted by the Proposed Action (24JF942, -944, and -1095). An additional 16 sites eligible or potentially eligible to the NRHP are located within the cumulative effects area for the Proposed Action and could experience impacts related to future exploration activities. These include sites 24JF292, -296, -712, -717, -762, -1062, -1063, -1069, -1073, -1077, -1089, -1090, -1092, -1097, -1106, and -1123 (see Table IV-17).

IV.O.3.m Native American Concerns

Disturbance to traditional lifeway values of Native Americans and other ethnic groups from developments associated with past and present projects and exploration activities could occur in the cumulative effects area if they have not been previously identified. No Native American religious use areas have been identified in the cumulative effects area through contact with potentially affected tribal groups; however, consultation with the appropriate tribal councils would be required under the American Indian Religious Freedom Act of 1978 prior to any future actions in the cumulative effects area on public lands.

Talus pits, located west of the permit boundary and identified by representatives of the Shoshone-Bannock Land Use Policy Commission and the Flathead Culture Committee as important cultural properties, are protected under a patent restriction developed between the BLM, the SHPO, and GSM. Any disturbance to these patent-protected sites could result in legal action. No additional cultural properties of importance to Native Americans have been identified in the cumulative effects area.

IV.P POTENTIAL MITIGATION AND MONITORING

IV.P.1 Geology, Minerals, and Paleontology

Issue: Future slide block movement.

Measure G-1: Geodetic monitoring programs to detect ground movements associated with the landslide blocks at Golden Sunlight Mine are described in the Operating Permit. This measure is currently in place and would be continued for all alternatives. Current reporting is on a monthly basis. In addition to geodetic monitoring, the mine also monitors inclinometers and piezometers. These data are reported annually. If any new movement of the slide blocks is detected, the appropriate agencies would be notified promptly, and monitoring intervals and reporting frequencies increased as appropriate. Protocols have been developed for actions to be taken if renewed ground movement is detected.

Agency notification and review of block stability will occur if any of the following criteria are exceeded:

- An average groundwater increase in the Bozeman Unit within the Sunlight Block of greater than 1 foot during any 1-month period;
- A cumulative, average groundwater level increase of 10 feet in the Bozeman Unit within the Sunlight Block, with respect to November 1994 levels;
- If movement is indicated by inclinometers located within the Sunlight Block; or
- If consistent movement trends are discernible from geodetic monitoring data over a period of 2 months or more.

Effectiveness: This measure would provide for detection of any further ground movements in the identified slide block areas. If movement is detected, appropriate mitigation measures could be taken to re-establish stability. Such measures could include, redistribution of waste rock , dewatering, recontouring, and buttress construction in slide areas. These measures were used to successfully address the slide block movements experienced in 1994.

Application: This measure would apply to all alternatives, including the No Action Alternative.

Issue: Potential ground movements in the East Waste Rock Dump.

Measure G-2: Geodetic monitoring programs to detect ground movements associated with the East Waste Rock Dump areas would be implemented, similar to those currently used at the existing slide block area and described in the Operating Permit. If any ground movements are detected, the appropriate agencies would be notified promptly, and monitoring intervals and reporting frequencies would be increased as appropriate. Protocols would be developed for actions to be taken if ground movement is detected, similar to those outlined in Measure G-1.

Effectiveness: This measure would provide for detection of any ground movements in the East Waste Rock Dump. If movement is detected, appropriate mitigation measures could be taken to re-establish stability.

Application: This measure would apply to all alternatives except the No Action Alternative.

Issue: Movement of structural foundations.

Measure G-3: Early warning of plant site movement is being provided by Sunlight Block monitoring, (Measure G-1). A stability monitoring program for the ore processing facilities also has been initiated. In addition to the primary (Sunlight Block) movement monitoring, ore processing facilities are monitored as follows:

- Weekly monitoring of all reagent tanks and critical mill components with 76 EL Beam sensors. Movement data are collected from each sensor on a weekly basis.

- Weekly monitoring of concrete slabs and foundations using extensometers installed throughout the mill, shops, crushers, and plant site.
- Monthly optical level surveys of the grinding mill pedestals.

These measures would be continued. If adverse movement is detected, the appropriate agencies would be promptly notified, and appropriate steps taken to ensure the safety of employees and protection of the environment.

Effectiveness: This measure would provide for detection of any movements within the ore processing facilities area. If movement is detected, appropriate mitigation measures could be taken to re-establish stability. Such measures could include draining of processing fluids to the tailings impoundments, and structural refitting of facilities to accommodate movements. These measures were used to successfully address the movements experienced in 1994.

Application: This measure would apply to all alternatives, including the No Action Alternative.

Issue: Damage to tailings impoundment caps due to consolidation settlement.

Measure G-4: Settlements in the tailings impoundments, which are expected over time as consolidation occurs, could result in differential settlements of the impoundment reclamation caps. Such differential settlements could result in ponding of surface water or disturbance of the cover in such a way as to reduce the cover effectiveness in preventing infiltration. Such damage can be mitigated by maintenance activities which would include regrading of the impoundment surface in affected areas, and repair of the cover as needed to restore its function and maintain the desired slopes on the impoundment surface.

Effectiveness: Maintenance activities performed as needed to the impoundment surface and the tailings caps would be effective in maintaining cover integrity and function.

Application: This measure would apply to all alternatives, including the No Action Alternative.

Issue: Construction feasibility concerns regarding pit backfilling activities under the Partial Backfill Alternative.

Measure G-5: Worker safety and stable cover of pit wall surfaces are concerns for the proposed placement of backfill in the pit under the Partial Backfill Alternative. In order to address these concerns, an evaluation would be made of potential alternatives for construction. Such construction alternatives could include the following:

- Construction of the pit wall backfill by working up from the bottom of the pit, rather than end dumping. While this option would result in placement of a more consistent fill with reduced risk to workers, it would require greater volumes of backfill material against the pit walls (up to 5 or 6 times as much), and may be cost prohibitive; or
- Use of remote-controlled equipment for grading of the pit wall cover slopes, to avoid safety risks to workers.

Effectiveness: Alternative construction methods would entail considerable additional costs, and would not likely be cost-effective in producing a reliable long-term reclamation plan.

Application: This measure would apply to the Partial Backfill Alternative.

Issue: Direct impacts to previously unidentified paleontological resources.

Measure P-1: If previously undocumented paleontological deposits are located during project operations, GSM would cease activities in the area until the resources could be examined by professional paleontologists approved by the state and/or BLM. If significant paleontological resources are identified, impacts would be mitigated through an appropriate treatment plan approved by the state and/or the BLM, or through site avoidance.

Effectiveness: This measure would allow for the evaluation of previously unknown and potentially significant paleontological deposits that may be discovered during mining activities. It also would provide adequate time for presentation and recovery of the resources if this is deemed necessary by the state or BLM.

Application: This measure would apply to all alternatives.

IV.P.2 Water Resources

Issue: Identification and replacement of reduced discharge or reduced water quality at springs and seeps.

Measure W-1: A monitoring program would be established to quantify discharge and water quality at springs in the project area, and to identify any reductions in flow or water quality. Data collection events would be frequent enough to detect spring response to seasonal variations and pit dewatering.

Mitigation of reduced discharge at springs would be accomplished by further development of the affected spring or by diverting water from the permanent water treatment plant to provide water for wildlife and livestock use. Further development of the spring would involve improving collection and storage of spring discharge and/or expanding the interception area of the spring at the water table.

Mitigation of reduced water quality would be accomplished by establishing additional water sources for wildlife and livestock use. Additional water sources would be obtained from treated water discharged from the permanent water treatment plant. The treated water would be discharged as surface water in a manner that provides a wildlife/livestock beneficial use area.

Effectiveness: This measure would document variations in spring discharge and spring water quality and provide data to determine if changes in spring flows or water quality are occurring as the result of mining activities. This measure also would provide continued surface water sources at the mine site, greatly reducing impacts to wildlife and livestock.

Application: This measure would apply to all alternatives.

Issue: Pit groundwater discharge to adjacent hydrostratigraphic units.

Measure W-2: Pit pond water levels would be monitored to ensure that the pit pond elevation remains below the groundwater discharge threshold elevation of 5,050 feet. If the pit pond level exceeds elevation 5,050 feet, appropriate measures would be taken to reduce the pond level. Such measures would include additional pumping and/or water treatment facilities.

Water level and water quality downgradient of the pit also would be monitored to confirm that a maximum pond elevation of 5,050 is effective in eliminating pit discharge to adjacent stratigraphic units. The 5,050 elevation was derived from modeling studies, and the appropriateness of this estimate should be verified. Such monitoring would indicate if adjustments are needed to this proposed maximum pond elevation in order to protect groundwater outside the pit.

Effectiveness: This measure would prevent pit pond water levels from exceeding the threshold discharge elevation, and thus mitigate the potential for degradation of the surrounding groundwater.

Application: This measure would apply to all alternatives where ponding in the pit would occur. This measure also would apply to the Partial Backfill Alternative, which would require maintaining the groundwater surface at or below elevation 5,050 although no open pond would remain in the pit. Monitoring of groundwater levels would be done via monitoring wells instead of pond level.

***Issue:* Erosion from increased flows in stream channels due to the Sheep Rock or return diversion.**

Measure W-3: Under the Proposed Action, increased erosion could occur within Conrow Creek and the tributary to Conrow Creek following the introduction of additional flows from Sheep Rock Creek. Under the Return Diversion Alternative, increased erosion could occur within the unnamed tributary to Sheep Rock Creek as a result of diverted flows. Periodic examination of these channels and maintenance would be performed. Maintenance would include the addition of erosion protection in affected channel reaches, and/or installation of check dams or other grade control structures. GSM has committed to visually inspecting Conrow Creek after storm events and addressing channel damage. This would apply for the unnamed tributary to Sheep Rock Creek under the Return Diversion Alternative.

Effectiveness: Periodic examination of channels and maintenance as needed would mitigate erosion from increased flows in Conrow Creek, the tributary to Conrow Creek, or the unnamed tributary to Sheep Rock Creek.

Application: This measure would apply to the Proposed Action, and to other alternatives which would include the diversion of Sheep Rock Creek into Conrow Creek; this measure would apply to the Return Diversion Alternative for the unnamed tributary to Sheep Rock Creek.

***Issue:* ARD release from waste rock dumps that is either premature because of transport along preferential, discrete flow paths, and/or of greater flow rate than modeled performance because of higher than expected infiltration.**

Measure W-4: If the data from existing monitoring wells and/or spring flows indicate that changes in water quality are occurring which are likely to exceed applicable regulatory requirements, the following mitigation measures would be employed:

a) If water quality impacts are detected in monitoring wells at the mixing zone boundary downgradient from the East Waste Rock Dump, localized capture of groundwater may be needed to contain ARD transport along preferential, discrete flow paths that were not anticipated by the ARD fate and transport model (see Appendix J). A groundwater capture system similar to the system described in Appendix A for the West Waste Rock Dump would be installed. Capture of discrete plumes from the East Waste Rock Dump would not require a well system as extensive as assumed for the West Waste Rock Dump. The contingency design in Appendix A that provides for treatment of approximately 20 percent of the predicted flux on the east side is considered adequate for this mitigation measure.

b) ARD-impacted seeps may emerge at the toes of the dumps where preferential drainage paths occur within the dumps that lead to discrete "perched" saturated zones at their base. Shallow groundwater capture systems such as toe drains around the peripheries of the waste rock dumps would be installed to supplement the primary, deep capture well system; or

c) *In situ* treatment systems would be installed in the shallow ("perched") aquifer zones, including the alluvial materials over bedrock on the west side, and/or the colluvial/alluvial materials in Rattlesnake Gulch or at other locations downgradient of the East Waste Rock Dump. One example of this type of emerging technology is a funnel and gate approach which incorporates groundwater barriers that "funnel" the identified contaminant plume(s) through constrained location(s) within the shallow aquifer. *In situ* reaction walls, such as limestone-filled trenches, are installed at these "gate" locations. The reaction walls provide essentially "semipervious" barriers which allow water to pass but "filter" the dissolved metals or other contaminants.

Effectiveness: The supplemental groundwater capture systems described would allow interception of contaminated groundwater that bypasses the primary capture well system. ARD-impacted groundwater could bypass the capture wells along shallow perched flow paths around the peripheries of all the dumps, or move through high conductivity preferential flow paths downgradient from the East Waste Rock Dump. The supplemental systems described will provide for capture of these potential ARD sources before the contaminated water migrates downgradient to beneficial uses, or to sensitive receptors, such as the Jefferson River.

Application: These measures would apply to all alternatives.

Issue: Impacts to beneficial uses of water downgradient of capture system because of capture, drawdown effects.

Measure W-5: Water would be discharged from the permanent water treatment plant back to the aquifer as recharge, or to discharge as surface water in order to minimize impacts to downgradient beneficial uses.

Effectiveness: This measure would minimize impacts to beneficial uses of water downgradient of the groundwater capture system.

Application: This measure would apply to all alternatives.

Issue: Total of combined inflows to permanent water treatment plant exceed the capacity of the plant.

Measure W-6: The capacity of the permanent water treatment plant would be reevaluated and incorporated into the final design within two years prior to mine closure. At that time, the actual rate and quality of pit inflow during peak flow and low flow periods, and the total rate and quality of groundwater captured in the tailing area will be better known.

Based on the degree of uncertainty of the rate of inflow from future sources, a contingency measure of up to 25 percent additional flow would be incorporated into the treatment plant capacity, and a contingency to provide storage for up to 6 months of anticipated water inflow would be included. This would provide for time to modify the plant if needed for unanticipated future inflows.

Alternatively, a new, additional water treatment facility would be constructed to address treatment of a specific source or sources. This supplemental water treatment facility would be built at the time such sources are identified. This alternative measure may be considered for treatment of waste rock dump ARD because the time frame before ARD impacts are anticipated to occur is longer than a reasonable design life of the permanent water treatment plant that will be built at the end of mining.

Effectiveness: Sufficient additional water treatment capacity, whether added to the permanent water treatment plant design or as an additional separate facility, would provide for treatment of unanticipated inflows.

Application: This measure would apply to all alternatives.

Issue: Cracking of tailings impoundment covers due to desiccation and/or freeze-thaw effects.

Measure W-7: The 18-inch clay layer of the cover for Tailings Impoundment No. 1 would be replaced with an additional 18 inches of agency-approved alluvial borrow material. The additional 18-inch layer of alluvial borrow material is not needed for the lined Tailings Impoundment No. 2.

Effectiveness: Field studies indicate that this will enhance the cover system over the unlined Tailings Impoundment No. 1 and help to minimize the seepage that needs to be collected and pumped back for treatment.

Application: This measure would apply to the No Action Alternative. All other alternatives utilize the cover described in this mitigation measure, substituting local borrow for the clay layer.

Issue: Leakage from HDPE liner system underlying Tailings Impoundment No. 2 and reclaim ponds.

Measure W-8: If the data from existing monitoring wells indicate that the Tailings Impoundment No. 2 and/or reclaim ponds liners are leaking, pumpback wells would be installed as needed to effectively contain any impoundment fluid plumes. It is anticipated that pumpback systems installed to contain Tailings Impoundment No. 2 leaks would require similar pumpage rates per well as are currently being used for pumpback groundwater control at Tailings Impoundment No. 1. However, it is unlikely that as many wells would be needed as are in operation on Tailings Impoundment No. 1 because the leakage from Tailings Impoundment No. 2 is likely to be localized, the underlying compacted clay materials have very low permeabilities, and the hydrogeologic conditions under Tailings Impoundment No. 2 are more favorable. The pumpback flows would have to be treated in an enlarged or supplemental water treatment facility, as described under Mitigation Measure W-7.

Effectiveness: Groundwater interception and pumpback have been shown to be effective for controlling seepage from Tailings Impoundment No. 1, and would likely also be effective for containing leaks from Tailings Impoundment No. 2 and/or the reclaim ponds.

Application: This measure would apply to all alternatives.

Issue: Preventing contact between natural groundwater and tailings material in Tailings Impoundment No. 1 in order to reduce or eliminate the mobilization of cyanide, TDS, and ARD constituents.

Measure W-9: Prior to mine closure, a trench-drain upgradient of Tailings Impoundment No. 1 would be constructed within the Rattlesnake hydrostatic unit, the known source of water to the historic spring at the north end of the impoundment. The trench drain would be designed to intercept between 20 and 30 percent (40 to 60 gpm) of the estimated Rattlesnake unit groundwater flux (200 gpm) and route this water by gravity drainage to a percolation pond away from the impoundment area. This measure would lower the groundwater table within the Rattlesnake unit downgradient of the drain and beneath the former spring area such that the hydraulic contact between groundwater and tailings is eliminated. The success of this system would be monitored for a sufficient amount of time prior to mine closure so that the results could be incorporated into the final design of the water treatment plant.

Alternately, one or more dewatering wells could be constructed through the tailings impoundment and into the underlying Rattlesnake unit in the former spring area.

Effectiveness: A trench-drain upgradient of Tailings Impoundment No. 1 would reduce the groundwater flow beneath the impoundment, reducing the amount of cyanide, TDS, and ARD constituents that could be mobilized in groundwater beneath the impoundment.

Application: This measure would apply to all alternatives.

Issue: Identification of bedrock fractures to optimize efficiency of the west side groundwater capture system.

Measure W-10: A hydrogeologic investigation of the bedrock hydrostratigraphic unit on the west side of the project area would be conducted to identify major water-bearing fractures for purposes of monitoring and future groundwater capture of dump seepage. The study would be comprised of geologic mapping, test well drilling, and aquifer testing. The results of the study would be used to determine optimum groundwater monitoring locations and to design a groundwater capture system to prevent impacts to beneficial water uses.

Effectiveness: A hydrogeological investigation to identify major water-bearing fractures on the west side of the project area would increase the efficiency of the proposed groundwater capture system that is designed to prevent impacts to beneficial water uses.

Application: This measure would apply to all alternatives.

Issue: Damage to the permanent diversion of Sheep Rock Creek at less than the design flows (one-half PMF), exposing waste rock to surface water flows.

Measure W-11: Any damage which occurs to the permanent diversion channels during flow events less than the designated design flow criteria would be monitored during scheduled operational inspections. Any such damage would be repaired as part of scheduled operational maintenance activities, restoring the affected channel reaches to their original capacity and condition.

Effectiveness: Scheduled inspection and maintenance of permanent diversion channels would allow timely repair of any damage to channels which could compromise their intended performance.

Application: This measure would apply to all alternatives which utilize permanent diversion of Sheep Rock Creek.

IV.P.3 Soils and Reclamation

Issue: Monitoring and testing of soils affected by steam venting at the waste rock dump test plots and tracking number and size of vents on all reclaimed surfaces over acid-producing materials.

Measure S-1: A program for the continued monitoring of existing waste rock test plots to further assess the impacts, if any, that steam venting may have on reapplied soil or establishing vegetation would be implemented. The program would consist of GSM or agency reclamation specialists annually monitoring the number, location, and size of steam vents and extent of modified plant communities surrounding vent locations. If detrimental effects to establishing vegetation communities are observed on more than 0.1 percent of the total reclaimed area covering acid-producing materials, GSM would be required to: 1) rock armor vent locations to prevent erosion and spreading of vent locations, 2) sample and test soils at vent locations, and 3) prepare a detailed plan to further reduce the expansion of steam vents and minimize potential impacts to reclamation success. Soil parameters to be tested would correspond to those which appear to have given rise to the change in vegetation communities. At a minimum, soil pH and ABA should be evaluated for each sample collected. The general cost for such a program should be included in a post-mine maintenance bond.

Effectiveness: This would be an effective means of assessing and mitigating the changes occurring, if any, through time to reapplied soil materials and vegetation communities as a result of steam venting. The results of testing would be directly applicable to assessing whether steam venting had a negative effect on establishing vegetation communities.

Application: This measure would apply to all alternatives.

Issue: Salvaging or providing a sufficient volume of oxide rock, soil, or borrow material for capping needs under the No Action Alternative.

Measure S-2: GSM would include in the Company's bond calculations the provision for salvaging a sufficient volume of oxide rock, soil or borrow material to make up for the projected shortfalls of suitable capping material under the No Action Alternative. The calculations would be based on the volume of capping material needed, the volume of material available from various sources, and the distance to the two to three closest sources of oxide rock, soil, or borrow material to account for a reasonable haulage factor.

Effectiveness: High in terms of providing for sufficient capping needs and promoting reclamation potential.

Application: This measure would apply to the No Action Alternative only.

Issue: Salvaging a sufficient volume of soil (or borrow material) for reclamation under the No Action Alternative and Divided Dump Alternative (minimum disturbance scenario).

Measure S-3: The agency engineer would identify which soil stockpiles and which areas to be resoiled would be affected by the projected soil or borrow material shortfall. Continuing agency review of annual mine reports would provide the basic information with which to identify projected shortfalls. A salvage area would be identified and a bond calculation made to recover the needed volume of soil or borrow material at the time of reclamation. GSM would include in the Company's bond calculations the provision for salvaging a sufficient volume of soil material to make up for the projected shortfalls under either alternative. The calculations would be based on the volume of soil needed, the volume of soil available from various material sources, and the distance to the two to three closest sources of soil (or borrow) material to account for a reasonable haulage factor.

Effectiveness: High in terms of providing for sufficient bond funds to address the soil volume shortfalls.

Application: This measure would apply to the No Action Alternative and Divided Dump Alternative (minimum disturbance scenario).

Issue: Providing for application of soils containing high (up to 50 percent by volume) rock fragment contents on 2:1 and 3:1 waste rock dump slopes as a part of the reclamation cap proposed for waste rock dumps.

Measure S-4: Based on the results of on-site studies, GSM would use soils containing high (up to 50 percent by volume) rock fragment contents as part of the reclamation cap proposed for waste rock dumps. A combination of alternate erosion control techniques may be used in lieu of the proven high rock fragment content soils, if it can be shown that the substituted technique(s) will provide the same effect with regard to reducing erosion potentials on reclaimed slopes.

Effectiveness: High in terms of reducing erosion potentials for reclaimed areas, particularly steep slopes.

Application: This measure would apply to all alternatives.

Issue: Providing for mulch or a "mulch effect" as a part of the revegetation sequence proposed for disturbed areas during the reclamation phase of this project.

Measure S-5: Based on the results of on-site test plot studies, GSM would include mulching as part of the revegetation technique sequence proposed for disturbed areas at the project site. A combination of alternate mulching, cover crop, or seedbed manipulation techniques may be used in lieu of the proven mulching technique, if it can be shown that the substituted technique(s) will provide the same effect with regard to reducing erosion potentials and increasing revegetation success.

Effectiveness: High in terms of increasing revegetation success potential for disturbed areas, particularly steep slopes.

Application: This measure would apply to all alternatives.

Issue: Long-term success of waste rock and tailings revegetation using oxide waste rock and borrow material capping.

Measure S-6: The evaluation of existing waste rock test plots (initiated by Schafer and Associates) to assess the effectiveness of waste rock capping techniques developed on site would be continued until instrumentation ceases to function. Monitoring in this regard would consist of annually assessing the pH, NAG pH and ABA of the soil, soil/oxide cap transition zone, oxide cap, oxide cap/unoxidized waste rock transition zone, and unoxidized waste rock "horizons" to a sufficient depth (40 to 48 inches) to determine whether detrimental changes in these parameters are occurring within the root zone through time. Plant cover and species composition assessments would continue. Estimates of erosion also would be included based on soil surface features such as rilling, pedestaling, etc. A similar but abbreviated monitoring effort would be conducted at the tailings facility and selected waste rock dump sites to assess the potential for capillary rise from the tailings into the reapplied soil materials and acidification of reapplied soil over waste rock, respectively. The length of time that monitoring should continue would be decided upon by GSM, MDEQ, and the BLM.

Effectiveness: This would be a highly effective means of assessing the changes, if any, in seedbed materials through time as a result of the chemical characteristics of the material over which the soils were applied.

Application: This measure would apply to all alternatives.

IV.P.4 Vegetation and Wetlands

No mitigation measures are proposed for vegetation. See Appendix N for a detailed description of wetland mitigation measures.

IV.P.5 Wildlife and Fisheries Resources

Issue: Potential bat and avian contact with poor quality pit water.

Measure WF-1: When the pit lake forms, a monitoring program would be implemented to determine whether bat and avian species are utilizing the poor quality pit water for foraging or other activities. If this is occurring, a hazing program similar to that used for the tailings impoundments would be developed and implemented.

Effectiveness: This measure would minimize impacts to bat and avian species from contact with poor quality pit water.

Application: This measure would apply to all alternatives except the No Pit Pond and Partial Backfill Alternatives.

Issue: Loss of potential bat habitat.

Measure WF-2: An inspection or survey of existing mine shafts and adits would be conducted prior to initiation of mining activities to determine bat occupancy. GSM would notify the BLM prior to closing any shafts, adits, or man-made structures on BLM-managed land during mine operation. BLM would determine whether additional protection measures are necessary to prevent impacts to bat species that may inhabit these areas.

Effectiveness: These measures would prevent any direct impacts to bat species that may occupy abandoned underground openings. Long-term, indirect impacts would still occur.

Application: This measure would apply to all alternatives, except the No Action Alternative.

Issue: Loss of raptor nesting habitat.

Measure WF-3: Raptor surveys would be conducted during the breeding season prior to the initiation of mining activities on previously undisturbed lands between March 1 and August 15. If an occupied breeding territory or active nest site is located, restrictions would be applied to all disturbance activities during the breeding season. Protection measures would be identified by the agencies to protect breeding raptors. Depending on the nest location in relation to the planned mining activities, protection measures may include construction constraints within 0.5 mile of the nest during the sensitive early periods of the breeding season (e.g., courtship and incubation). The historic raptor nest located north of the tailings impoundment should be avoided. If it cannot be avoided this nest should be removed outside the active breeding season (March 1 to August 15).

Effectiveness: Surveys would determine the potential for impacting breeding raptors during nesting, and the appropriate protection measures would prevent disturbance of breeding birds. Nest removal outside the breeding season would minimize the loss of annual productivity for breeding raptors.

Application: This measure would apply to all alternatives, except the No Action Alternative.

Issue: Loss of migratory bird nesting habitat.

Measure WF-4: Removal of native vegetation species on previously undisturbed lands in the project area would be prohibited between May 1 and July 31 to protect actively nesting migratory birds. As an option, breeding bird surveys approved by the agencies could be conducted during the breeding season and prior to site disturbance to identify whether occupied territories or active migratory bird nest sites could occur within the areas to be disturbed. If nesting migratory birds are not located during the survey, construction could proceed. If nesting migratory birds are found, GSM would coordinate with the agencies and, based on the bird species detected, the agency biologist would make recommendations on whether appropriate protection measures should be implemented (e.g., avoidance).

Effectiveness: Constraint periods for removal of native trees and shrubs would minimize the direct loss of migratory birds. Breeding bird surveys would identify any sensitive migratory bird breeding areas prior to site disturbances.

Application: This measure would apply to all alternatives, except the No Action Alternative.

IV.P.6 Threatened, Endangered, and Candidate Species

See Measures WF-1 and WF-2 in Section IV.P.5, Wildlife and Fisheries Resources.

IV.P.7 Air Quality

No mitigation measures are proposed for this resource.

IV.P.8 Land Uses and Plans

No mitigation measures are proposed for this resource.

IV.P.9 Aesthetic Resources

IV.P.9.a Visual Resources

No mitigation measures are proposed for this resource.

IV.P.9.b Noise

No mitigation measures are proposed for this resource.

IV.P.10 Social and Economic Resources

No mitigation measures are proposed for this resource.

IV.P.11 Hazardous Materials and Wastes

Issue: Generation of unnecessary hazardous waste due to spills of hazardous materials onto soils.

Measure HM-1: Mitigation of the amount of soil impacted and removed due to a spill of hazardous material could be accomplished by storing all hazardous materials in a berm lined with an impermeable layer, rather than a soil or gravel berm. Spills within the containment berm would then be recovered with a vacuum truck and either recycled or disposed of as necessary.

Effectiveness: This measure would reduce the impacts due to spills around tanks and storage vessels.

Application: This measure would apply to all alternatives.

Issue: Generation of unnecessary hazardous waste due to drainage from routine maintenance operations.

Measure HM-2: Mitigation of the amount of soil impacted and removed due to the drainage of areas such as equipment/truck wash stations and equipment maintenance facilities would be accomplished by means of collecting and draining all washout/runoff from the area into an oil/water separator before discharge to surface waters. Paving these areas such that washout/runoff collected in a central drain also would eliminate the impact to soil. Used oil sludge would then be recovered with a vacuum truck and either recycled or disposed of as necessary.

Effectiveness: This measure would reduce the impacts due to the uncontrolled runoff of equipment wash rinsate.

Application: This measure would apply to all alternatives.

Issue: Generation of unnecessary hazardous waste due to improper handling and/or response to hazardous material spills.

Measure HM-3: Mitigation of the impacts due to a minor spill of hazardous material would be accomplished by training all personnel in the proper reporting and response requirements. Rapid and appropriate response to minor releases of hazardous material would reduce the amount of soil and/or water that would be impacted. Requiring all personnel to have OSHA hazardous material training would reduce the chance of accidents in storage and transport of hazardous materials and increase overall safety.

Effectiveness: This measure would increase worker awareness of hazardous material dangers and reduce the impacts due to spills.

Application: This measure would apply to all alternatives.

IV.P.12 Cultural Resources

Issue: Direct impacts to known cultural resources.

Measure C-1: Data recovery would be conducted at NRHP sites eligible under criteria "d" directly impacted by mining activities and would be carried out in accordance with a formal treatment plan prepared by a professional archaeologist and approved by the BLM, the MDEQ, the SHPO, and the ACHP prior to project commencement. Mitigation for directly affected sites eligible to the NRHP under criteria a, b, and c also would be addressed in a treatment plan, and would include such measures as information kiosks and artifact displays.

Effectiveness: This measure would mitigate adverse effects from direct impacts through data recovery, collection of available site information, and educational measures as determined on a site by site basis, and would meet legal requirements under 36 CFR 800.

Application: This measure would apply to all alternatives.

Issue: Indirect impacts to cultural resources from mining activities.

Measure C-2: Mitigation of indirect impacts would be accomplished by limiting access to archaeological sites on private land, education of GSM employees as to the fragile nature of cultural resources, and a strict GSM management policy regarding casual collecting of artifacts from project lands.

Effectiveness: This measure would reduce, but not eliminate, indirect impacts to cultural resources on both public and private lands.

Application: This measure would apply to all alternatives.

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Issue: Surveying of project areas previously uninventoried.

Measure C-3: Class III surveys by qualified archaeologists would be conducted in those areas of Section 36 that have not been previously inventoried if disturbance in those areas is planned. Surveys would occur before disturbance and before issuance of the ROD. Any potential effects to sites identified in these areas would be considered through the Section 106 process.

Effectiveness: This measure would identify and assist in mitigating adverse effects to currently unidentified sites that may occur in the unsurveyed areas.

Application: This measure would apply to the Divided Dump Alternative.

IV.P.13 Native American Concerns

Issue: Consultation on previously unidentified sites of potential significance to Native Americans.

Measure NA-1: If Class III surveys conducted in Section 36 (see Measure C-3) identify sites of potential concern to Native Americans, local tribal representatives would be consulted to determine if the sites should be considered as important traditional cultural properties, and if so, to further determine the appropriate mitigation measures to avoid adverse impacts.

Effectiveness: This measure would assist in identifying and mitigating adverse effects to currently unidentified sites that may be of significance to Native Americans.

Application: This measure would apply to the Divided Dump Alternative.

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IV.Q UNAVOIDABLE ADVERSE IMPACTS

Implementation of the environmental protection measures (see Chapter II) and the potential mitigation measures identified earlier in this chapter would reduce most adverse impacts that would result from the Proposed Action. Those unavoidable adverse impacts that would remain are summarized below by resource. Unavoidable adverse impacts for the action alternatives would be the same as those for the Proposed Action, except where specifically noted. Tables II-23 and II-24 provide a summary comparison of impacts among alternatives.

IV.Q.1 Geology, Minerals, and Paleontology

Unavoidable adverse impacts associated with all of the alternatives include the displacement and redistribution of rock materials from within the pit, into the waste rock dumps and the tailings impoundment. The minerals removed via the mining operations would no longer be available as a potential resource.

Placement of mine waste may limit access to potential fossil-bearing deposits, particularly in Sections 21, 28, and 29, and prevent future study of the areas. Previously unidentified paleontological resources could be encountered and/or directly impacted during the course of mine operation and reclamation.

IV.Q.2 Water Resources

Unavoidable impacts to surface water and groundwater quantity and quality include impacts associated with the pit dewatering, surface water diversions, tailings impoundments, and waste rock dumps.

Dewatering the pit will reduce groundwater levels in the pit vicinity during operation. Continued pumping of groundwater for treatment as part of reclamation will result in groundwater levels which are reduced from those naturally occurring for as long as pumping continues (in perpetuity). The reduced groundwater levels could impact discharges from local seeps and springs. The extent of the impacts would depend upon the proposed pit pumping levels, which vary between the alternatives as discussed in Section IV.B, Water Resources. Mitigation Measure W-1 would reduce impacts to seeps and springs from pit dewatering to the maximum extent practical. Intercepted pit water is removed from the local hydrologic system. During operation, this water is consumed in the processing circuit. Following mine closure and reclamation, most of this water would be returned to the local groundwater and surface water systems via the permanent water treatment plant.

Reclamation for all of the alternatives, including the No Action Alternative, require permanent diversion of surface water flows around waste rock dumps, the pit, and tailings impoundment. In the No Action Alternative and other alternatives which do not include diversion of Sheep Rock Creek flows into Conrow Creek, all surface flows affected by mine activities would be kept within only the drainage basins affected by the No Action Alternative. Although flows are being redirected within the basins, once reclamation is completed the impacts of these changes would not significantly alter total runoff volumes, erosion, or sedimentation with the basins. The Proposed Action includes permanent diversion of flows from Sheep Rock Creek above mine-affected areas into another drainage basin, via Conrow Creek, which would otherwise be unaffected by the mining activities. Under the Proposed Action, any impacts due to the additional flows introduced to the drainage would be mitigated by Measure W-3.

ARD produced in the waste rock dumps are expected to seep vertically through unconsolidated sediments underlying waste rock dumps to the groundwater environment. The potential to intercept this flow prior to reaching groundwater seems improbable and, thus, ARD impact on the groundwater system immediately adjacent to the waste rock dumps in the long-term appears unavoidable. The impact will be most strongly felt below the West Waste Rock Dump located on the western flank of Bull Mountain where underlying materials have minimal buffering capacity. The sedimentary material underlying the East Waste Rock Dump has some finite capacity to attenuate the migration of ARD. The Proposed Action contains provisions for monitoring groundwater quality and installing a capture system to contain any detected ARD plumes. It is technically feasible to install highly efficient capture systems, even in the fractured bedrock zones, but a small percentage of ARD bypassing the capture systems is likely to be unavoidable. The impact of this small amount of ARD downgradient of the capture system will be mitigated by buffering and dilution mechanisms in the aquifer systems.

IV.Q.3 Soils and Reclamation

The loss of 10,000 years of soil development would occur where soils are salvaged for reapplication during mine operations. This disturbance would result in the loss of some desirable edaphic characteristics that soils develop over time. Soil salvage and stockpiling plans, seedbed manipulation techniques, oxide capping approaches, and one- or two-lift soil reapplication methodologies have been developed to reduce these impacts to an acceptable level.

Subsoils in areas not revegetated, and those not salvaged prior to mining operations would be buried or otherwise withdrawn from productivity. A small volume of soils would be lost to erosive forces during salvage and reapplication activities and following seeding until vegetation becomes established.

IV.Q.4 Vegetation and Wetlands

Residual impacts to vegetation include the removal or disturbance of vegetation and change in vegetation composition (i.e., tree and shrub-dominated communities to grass- and forb-dominated communities) as a result of mine expansion. Species diversity would be reduced and invasion of noxious weeds would increase in disturbed ares. Areas not revegetated would experience a permanent loss of vegetation.

No wetlands would be directly filled by the proposed mine expansion; however, indirect hydrologic impacts could occur to area springs. These impacts would be compensated by off-site mitigation (see Appendix N), resulting in no residual impacts to wetlands resources.

IV.Q.5 Wildlife and Fisheries Resources

Short-term loss of 407 to 741 acres of native wildlife habitat would occur, depending on the alternative selected. This would cause a loss of small mammals, displacement of terrestrial wildlife species other than mule deer, increased habitat fragmentation, increased competition of displaced animals on adjacent areas, short-term habitat loss for breeding and foraging raptors, and loss of habitat for migratory birds. Over the long-term, reclamation would restore some form of wildlife habitat, but noxious weed species would increase, and plant species diversity would be reduced, thereby decreasing the diversity of wildlife habitats.

IV.Q.6 Threatened, Endangered, and Candidate Species

No unavoidable adverse impacts have been identified for this resource.

IV.Q.7 Air Quality

No unavoidable adverse impacts have been identified for this resource.

IV.Q.8 Land Uses and Plans

Unavoidable adverse impacts for land use include areas disturbed by mining activity and the loss of grazing resources in the Bull Mountain Allotment and Hill and Wilkerson Allotment. Portions of state school trust mineral estate would become inaccessible due to placement of permanent structures over state subsurface lands; however, the MDNRC requires condemnation drilling and analysis, and compensation for loss of mineral resources.

IV.Q.9 Aesthetic Resources

IV.Q.9.a Visual Resources

Although reclamation would reduce visual contrasts through recontouring and revegetating, the scale of visual disturbance caused by man-made forms would remain. Pit excavations and waste rock dumps create permanent large-scale changes in the visual landscape.

IV.Q.9.b Noise

Noise impacts from the proposed project would be minimal. No unavoidable adverse impacts exist for noise.

IV.Q.10 Social and Economic Resources

Unavoidable adverse impacts for social and economic resources include the eventual loss of employment provided by the Golden Sunlight Mine, tax revenues for the state and county, and income and other economic benefits in the county and local communities. Under the No Action Alternative, this loss would occur in 1997. Under the Proposed Action, losses would occur beginning around 2001 as employment is phased out through the end of the reclamation period. Mine operation would cease in 2006; the majority of tax contributions would cease at this point. Impacts for all other alternatives would be the same as those described for the Proposed Action. Impacts may be partially offset by efforts at the state, county, school district, and community level to retrain workers, diversify the economic base, and provide public finance alternatives upon mine closure.

IV.Q.11 Hazardous Materials and Wastes

There would be no significant unavoidable adverse impacts due to hazardous materials use and storage at the site under this alternative that would remain following the implementation of the mitigation measures identified.

IV.Q.12 Cultural Resources

Direct and indirect impacts to cultural resources would result in permanent loss of site context and traditional use, and in the case of sites indirectly impacted, potentially the loss of information and artifacts.

IV.Q.13 Native American Concerns

Previously unidentified sites of potential concern to Native Americans could experience unavoidable direct and indirect impacts.

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IV.R SHORT-TERM USE VERSUS LONG-TERM PRODUCTIVITY

Short-term is defined as the life of the Golden Sunlight Mine through closure and reclamation (2016). Long-term is defined as the future beyond reclamation. Many of the impacts associated with the Proposed Action would be short-term and would cease following successful reclamation.

Soil and vegetation short-term productivity would be reduced. Assuming revegetation is successful, and soil development and vegetation succession occur, long-term soil productivity would be restored. This also appears to be true for tree and woody plant communities.

Overall, it appears from the test plots evaluated to date that soil productivity can be maintained at predisturbance levels on all areas subject to revegetation activities. On project facilities not to be revegetated, such as portions of the pit, soil productivity would be lost. The volume of subsoil materials not salvaged prior to mining, or waste rock and tailings deposition, and considered unsuitable or unnecessary for salvage and revegetation, would be permanently lost in terms of soil productivity.

IV.8 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Continued operation of the Golden Sunlight Mine could result in either the irreversible or irretrievable commitment of certain resources. Irreversible is a term that describes the loss of future options. It applies primarily to the effects of use of nonrenewable resources, such as minerals or cultural resources, or to those factors, such as soil productivity, that are renewable only over very long periods of time. Irretrievable is a term that applies to the loss of production, harvest, or use of natural resources. For example, livestock forage production from an area is lost irretrievably while an area is serving as a mining area. The production lost is irretrievable, but the action is not irreversible. If the use changes and the mine is reclaimed, it is possible to resume forage production. Irreversible and irretrievable impacts of the Proposed Action are summarized in Table IV-21.

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Table IV-21

Irreversible/Irretrievable Commitment of Resources - Proposed Action

Resource	Irreversible Impacts	Irretrievable Impacts	Explanation
Geology, Minerals, and Paleontology	Yes	Yes	Mineral resources that are mined would no longer be available for future production. Disturbance or restricted access to paleontological resources would represent a permanent (long-term) loss of data.
Water Resources	Yes	Yes	Dewatering the pit would reduce groundwater levels in the pit vicinity during mining operations and for as long as water is treated to meet water quality standards. ARD produced by waste rock dumps is expected to seep through unconsolidated sediments underlying waste rock dumps to the groundwater environment. Sheep Rock Creek flows would be permanently diverted into Conner Creek.
Soils and Reclamation	Yes	Yes	A loss of soil development in salvage areas would occur. Productivity of subsoils not salvaged, and in areas not revegetated would be lost. A small volume of soil would be lost to erosion during soil handling activities and as a result of diversion construction.
Vegetation and Wetlands	Yes	Yes	Irretrievable impacts would occur for all new disturbance in the project area. Irreversible impacts would occur for all areas not revegetated. Vegetation productivity on other disturbed lands is expected to recover in the long-term, following revegetation activities. Irreversible impacts would occur for area springs impacted hydrologically.
Wildlife and Fisheries Resources	Yes	Yes	Irretrievable loss of habitat would occur in areas revegetated. Irreversible loss of habitat would occur for 24 acres of disturbance in the pit, although the resulting modified habitat could benefit species such as bats.
Threatened, Endangered, and Candidate Species	Yes	Yes	Irretrievable loss of habitat would occur in areas revegetated. Irreversible loss of habitat would occur for 24 acres of disturbance in the pit, although the resulting modified habitat could benefit species such as bats.
Air Quality	No	No	No state or federal air quality standards would be exceeded.
Land Uses and Plans	Yes	Yes	Both temporary and permanent losses of grazing area would occur in the Hill and Wilkerson Allotment.

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Table IV-21 (Continued)

Resource	Irreversible Impacts	Irretrievable Impacts	Explanation
Aesthetic Resources	Yes	Yes	Disturbances created during mine operations would increase the areas of visual contrast not in compliance with the suggested VRM Class III rating. Reclamation would reduce contrasts to a level of compliance, but permanent, large-scale changes in the landscape (such as pit excavations and waste rock dumps) would remain.
Social and Economic Resources	No	Yes	The eventual loss of employment, tax revenues, and other economic benefits following mine closure are considered temporary over the long term, as other sources of employment and tax revenues would likely be obtained.
Hazardous Materials and Wastes	No	No	A spill of hazardous materials into a sensitive resource, such as a stream or wetland, is not expected during the life of the project. If one did occur, impacts could last for several months or years, but would not be considered irreversible. Remediation of a spill would be initiated immediately and should be able to mitigate most impacts.
Cultural Resources	Yes	Yes	Disturbance of cultural sites would result in the permanent loss of site context that could relate to potential future discoveries, and for indirectly affected sites, potentially the loss of information and artifacts.
Native American Concerns	Yes	Yes	Disturbance of previously unidentified sites of potential concern to Native Americans would represent a permanent loss of resources.

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IV.T ENERGY REQUIREMENTS AND CONSERVATION POTENTIAL

Energy for the Proposed Action would be supplied by electricity, propane, and diesel fuel. Electricity would be used to power all equipment in the process plant and ancillary facilities, pump water used in the operation, and provide lighting for mining and processing activities. The electrical load would be approximately 10.7 megawatts. Natural gas would be used to heat buildings, and about 2,333 mcf per year would be consumed. Diesel fuel would be used to power all mobile equipment and emergency back-up generators. About 0.27 to 1.90 million gallons per year would be used. Life-of-project energy consumption is presented below:

- Electricity - 865,000 Megawatt-hours
- Natural gas - 21,000 mcf
- Diesel fuel - 13 million gallons

In addition, the commitment to maintain and operate a water treatment plant in perpetuity would require an unknown and unlimited amount of energy. Current assumptions estimate a need of 800 megawatt-hours per year indefinitely.

Alternatives that would have an energy consumption different from the Proposed Action are the Divided Dump Alternative, 3:1 Slope Alternative, and Partial Backfill Alternative. These alternatives would have increased diesel fuel consumption for hauling waste rock longer distances, grading slopes to 3:1, or backfilling waste rock from the dumps into the pit. The life-of-project diesel fuel consumption for each alternative is presented below. These alternatives offer no conservation potential over the Proposed Action.

Divided Dump Alternative:

- Diesel fuel - 21 million gallons

3:1 Slope Alternative:

- Diesel fuel - 18 million gallons

Partial Backfill Alternative:

- Diesel fuel - 18 million gallons

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CHAPTER V

Consultation and Coordination

Draft Environmental Impact Statement Preparation [illegible]
Draft Environmental Impact Statement Review [illegible]

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V CONSULTATION AND COORDINATION

V.A DRAFT ENVIRONMENTAL IMPACT STATEMENT PREPARATION

In preparing the Draft Environmental Impact Statement, the Montana Department of Environmental Quality and the Bureau of Land Management communicated with and received input from many federal, state, and local agencies, as well as other organizations and individuals. The following is a list of those who provided input:

Federal Government Agencies

Department of Defense
  Army Corps of Engineers
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service

State Government Agencies/Universities

Montana Department of Fish, Wildlife, and Parks
Montana Department of Labor and Industry
Montana Department of Natural Resources and Conservation
  Trust Land Management Division
Montana Department of Revenue
State Historic Preservation Office
University of Montana

Local Governments

Cardwell School
Jefferson County Treasurer
Mayor of Whitehall
Whitehall School District

Private

Western Technology and Engineering, Inc.

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V.B DRAFT ENVIRONMENTAL IMPACT STATEMENT REVIEW

In the course of preparation of the Draft Environmental Impact Statement for the Golden Sunlight Mine Project, the Montana Department of Environmental Quality and Bureau of Land Management communicated with and received input from many federal, state, and local agencies; elected representatives; environmental and citizens groups; industries; and individuals. A mailer was sent to 231 individuals, organizations, and industries/businesses on the distribution list below in October 1997, notifying them of the availability of the Draft EIS and Summary. Approximately 300 copies of the Draft EIS and/or Summary were distributed by mail in November 1997 to those who responded to the mailer, and all agencies, representatives, organizations, and other addressees on the distribution list who did not receive the mailer.

Agencies, Organizations, and Individuals Who Received Copies of the Draft Environmental Impact Statement

Federal Agencies

Library of Congress - Washington, D.C.
U.S. Department of Defense
    Army Corps of Engineers - Omaha, NE; San Francisco, CA
    HQ - USAF/LEEV - Washington, D.C.
    Office of Deputy A/S of the USAF - Washington, D.C.
U.S. Department of Energy
    Office of Environmental Compliance (EH-23) - Washington, D.C.
U.S. Department of the Interior
    Bureau of Land Management - Billings, MT; Butte, MT; Spokane, WA; Washington, D.C.
    Bureau of Reclamation - Denver, CO
    Fish and Wildlife Service - Helena, MT; Washington, D.C.
    Minerals Management Service - Washington, D.C.
    National Park Service - Washington, D.C.
    Natural Resources Library - Washington, D.C.
    Office of Environmental Policy and Compliance - Washington, D.C.
    Office of Public Affairs - Washington, D.C.
U.S. Environmental Protection Agency - Helena, MT; Denver, CO; Washington, D.C.
    Office of Federal Activities - Washington, D.C.
    Region VIII Office - Denver, CO
U.S. Geological Survey - Reston, VA
U.S. Government Printing Office - Washington, D.C.

State Agencies

Department of Commerce, Hard Rock Impact Board - Helena, MT
Environmental Quality Council - Helena, MT
Montana College of Mineral Science and Technology - Butte, MT
Montana Department of Environmental Quality - Helena, MT
Montana Department of Fish, Wildlife, and Parks - Helena, MT
Montana Department of Natural Resources and Conservation - Helena, MT (5 copies)
    Minerals Management Bureau
    Special Uses Management Bureau
    Central Land Office
    Water Rights Bureau
Montana State Library - Helena, MT

Montana State University - Bozeman, MT
Montana Tech Library - Butte, MT
State Historic Preservation Office - Helena, MT

County Agencies

Jefferson County Commission - Boulder, MT
Jefferson Valley CD - Whitehall, MT

Local Agencies

Boulder Community Library - Boulder, MT
Bozeman Public Library - Bozeman, MT
Butte Public Library - Butte, MT
John Gregory Memorial Library - Whitehall, MT

Elected Officials

Commissioner Leonard Wortman - Boulder, MT
Commissioner Glenna Obie - Clancy, MT
Commissioner Sam Samson - Boulder, MT
Governor's Office - Helena, MT
Honorable Jack Rea - Three Forks, MT
Representative Duane Grimes - Clancy, MT
State Senator Mike Foster - Townsend, MT

Tribal Organizations

The Confederated Salish and Kootenai Tribes of the Flathead Nation - Pablo, MT
Crow Indian Reservation - Crow Agency, MT
Shoshone-Bannock Tribes - Fort Hall, ID

Organizations

AFFCO - Anaconda, MT
Alliance for the Wild Rockies - Missoula, MT
CED - Helena, MT
Center for Urban Affairs and Policy Research - Evanston, IL
Clark Fork Coalition - Missoula, MT
Continental Divide Trail - Baltimore, MD
CURE - Whitehall, MT
Earthworks - Missoula, MT
MEIC - Helena, MT
Mineral Policy Center - Bozeman, MT
Montana Mining Association - Helena, MT
Montana River Action Net. - Helena, MT
Montana Wildlife Federation - Ramsey, MT
National Wildlife Federation - Missoula, MT
Northern Plains Resource Council - Dillon, MT; Billings, MT
NVR - Missoula, MT
Pintler Audubon Society - Twin Bridges, MT

Industries/Businesses

Alpine Sports and Gifts - Whitehall, MT
Bozeman Chronicle - Bozeman, MT
Butte Standard - Butte, MT
Butte Local Development Corp. - Butte, MT
Corrette, Smith, Pohlman & Allen - Butte, MT
Cyprus Amax Minerals - Englewood, CO
Ernst & Young LLP - Denver, CO
First Bank of Butte - Whitehall, MT
Golden Sunlight Mine - Whitehall, MT
Gough, Shanahan, Johnson & Waterman - Helena, MT
Holme, Roberts & Owen - Denver, CO
Interstate Diesel Products - Missoula, MT
KTVM - Butte, MT
LCM Ltd. - Denver, CO
Maxim - Missoula, MT
Mediation & Public Management - North Ogden, UT
Mountain Labs - Bozeman, MT
Pegasus Gold Inc. - Jefferson City, MT
Phelps Dodge Corp. - Phoenix, AZ
Placer Dome U.S. Inc. - Elko, NV
SAIC - Helena, MT; McLean, VA
S. J. Perry Co. - Butte, MT
Tom Carey Cattle Co. - Boulder, MT
Whitehall Ledger - Whitehall, MT

Individuals

Gail & Phillip Amicucci - Whitehall, MT
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Paul and Luke Dale - Whitehall, MT
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Claude Daley - Twin Bridges, MT
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Marthanne Keough - Whitehall, MT
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Mike Kerns - Butte, MT
William Klein - Helena, MT
Mike Korer - Butte, MT
Rick Lambert - Clancy, MT
James Long - Helena, MT
Charles Larson - Whitehall, MT
Darryl Layne - Whitehall, MT
Joanne Layne - Whitehall, MT
Glenn Lewis - Butte, MT
Elmer Likes - Sheridan, MT
J.S. Loan - Butte, MT
James Loomis - Whitehall, MT
Charlene Lopez - Englewood, CO
Tom Lott - Twin Bridges, MT
Jack Lynch - Butte, MT
Mark & Carole Mackin - Whitehall, MT
John Magnus - Sheridan, MT
Bob Marks - Clancy, MT
Ray and Enid McCafferty - Whitehall, MT
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Arlen McCloskey - Butte, MT
William McDonald - Butte, MT
Robert McDowell - Cardwell, MT
Jim Miller - Whitehall, MT
Warle E. Micrd - Cardwell, MT
Mary Missle - Whitehall, MT
Tom MonForton - Whitehall, MT
Howard and Pat Mulligan - Cardwell, MT
Tim Mulligan - Whitehall, MT
Bill Nelson - Whitehall, MT
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Glossary
Acronyms and Abbreviations
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GLOSSARY

Acid-Base Accounting (ABA)	An evaluation of the potential for acid generation by comparing various levels and forms of acid-forming and acid-neutralizing materials found in ore or waste rock.
Acid Rock Drainage (ARD)	Water from pits, underground workings, waste rock, and tailings containing free sulfuric acid. The formation of acid drainage is primarily due to the weathering of iron pyrite and other sulfur-containing minerals. Acid drainage can mobilize and transport heavy metals which are often characteristic of metal deposits.
Acid generating potential	A material's potential to generate acid and produce acid drainage. Analytical tests used to assess acid generating potential are either static or kinetic.
Acid neutralizing potential	The measure of a carbonate material theoretically available to neutralize potential acid generated by ore or waste rock.
Adit	A horizontal or nearly horizontal access opening into an underground mine.
Adsorption	The adherence of molecules in solution to the surface of solids with which they are in contact. Dissolved gold adsorbs to activated carbon.
Alluvium	Unconsolidated sedimentary material, including clay, silt, sand, gravel, and mud, deposited by flowing water.
Ambient (air)	The surrounding atmospheric conditions.
Aquifer	A stratum of permeable rock, sand, etc, which contains water. Water source for a well.
Animal Unit Month (AUM)	The amount of forage required by one cow and calf, or their equivalent, for 1 month.
Archaeology	The science that investigates the history of peoples by the remains belonging to the earlier periods of their existence.
Archival	Pertaining to or contained in documents or records preserved in evidence of something.
Artifact	Any object showing human workmanship or modification especially from a prehistoric or historic culture.
Attenuate	To lessen, decrease, reduce a concentration.
Authorized Officer	BLM official(s) responsible for approval and implementation of BLM decisions regarding the Golden Sunlight Mine Expansion Project.

Bedrock	The solid rock that underlies gravel, soil, or other superficial material.
Benthic	Pertaining to the bottom of a body of water.
Berm	A horizontal, earthen structure, often constructed on exposed slopes, which increases slope stability, redirects the flow of water or other materials, or provides a place for sloughing material to collect.
Biological Assessment	An evaluation conducted on federal actions in accordance with the Endangered Species Act. The purpose of the assessment is to determine whether the proposed action is likely to affect an endangered, threatened, or candidate species.
Bond	A sum of money which, under contract, one party pays another party under conditions that when certain obligations are met, the money is then returned (such as after mining reclamation occurs).
Borrow Area	An area which provides a source of earthen construction material such as sand, gravel or topsoil for use in construction or reclamation.
Candidate, Category 1 (C1)	Taxa for which the United States Fish and Wildlife Service has substantial information on hand to support proposing the species for listing as threatened or endangered. Listing proposals are either being prepared or have been delayed by higher-priority listing work.
Candidate, Category 2 (C2)	Taxa for which the United States Fish and Wildlife Service has information to indicate that the listing as threatened or endangered is possibly appropriate. Additional information is being collected.
Candidate, Category 3 (C3)	Taxa that were once being considered by the United States Fish and Wildlife Service for listing as endangered and threatened but are no longer receiving such consideration.
CFR	Code of Federal Regulations. A codification of the general and permanent rules published in the Federal Register by the executive departments and agencies of the federal government.
Clean Water Act	Federal Water Pollution Control Act, as amended.
Cone of Depression	The geometry or shape of an inverted cone on the water table or artesian pressure surface caused by the pumping of a well. The cone of depression will disappear over time when well pumping ceases.

Contrast	The effect of differences in the form, line, color, or texture of a landscape's features.
Cooperating Agency	An agency designated by the lead agency that has jurisdiction over a project, by law, or special expertise on a relevant environmental issue.
Cretaceous	Span of time between 136 and 65 million years ago.
Cultural resources	Remains of human activity, occupation, or endeavor as reflected in sites, buildings, artifacts, ruins, etc.
Downgradient	At a lower point of elevation in relation to any fixed point with regard to the direction of drainage or flow.
Drawdown	Vertical distance that a water elevation is lowered or the pressure head is reduced due to the removal of water from the same system.
Edaphic	Pertaining to soils.
Endangered species	Any species of animal or plant that is in danger of extinction throughout all or a significant portion of its range. Plant or animal species identified by the Secretary of the Interior as endangered in accordance with the 1973 Endangered Species Act.
Endemic	Restricted, belonging, or native to a locality or region.
Environment	The physical, biological, and social conditions that exist within an area, including land, air, water, minerals, flora, fauna, social and economic values, and objects of historical, aesthetic, or cultural significance. The sum of all external conditions that affect an organism or community and ultimately determine its form and survival.
Environmental Assessment (EA)	A concise public document for which a federal or state agency is responsible that serves to: 1) Briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact; 2) Aid an agency's compliance with the National or Montana Environmental Policy Act (NEPA or MEPA) when no environmental impact statement is necessary; 3) Facilitate preparation of an environmental impact statement when one is necessary.

Environmental Impact Statement (EIS)	An analytical document prepared under the National Environmental Policy Act (NEPA) and Montana Environmental Policy Act (MEPA) that portrays potential impacts to the environment of a Proposed Action and its possible alternatives. An EIS is developed for use by decision makers to weigh the environmental consequences of a potential decision.
Ephemeral (streams)	Flowing in response only to direct precipitation.
Erosion	The group of processes whereby earth or rock material is loosened or dissolved and removed from any part of the earth's surface.
Fault	A fracture or fracture zone along which there has been displacement of the sides relative to one another parallel to the fracture.
Fault scarp	Steep rock faces formed by shearing of rock.
Ferricrete	Surficial sands and gravel cemented into a hard mass by iron oxide derived from the oxidation of sulfide minerals into solutions of iron salts.
Floodplain	That portion of a river valley, adjacent to the river channel, built of sediments and inundated with water at least once every 100 years.
Fluvial	Of or relating to a stream or river.
Freeboard	The distance from the surface of a pond to the top of a dam.
Geology	The science that relates to the earth, the rocks of which it is composed, and the changes that the earth has undergone or is undergoing.
Groundwater	Water found beneath the land surface in the zone of saturation below the water table.
Habitat	A specific set of physical conditions that surround a single species, a group of species, or a large community. In wildlife management, the major components of habitat are considered to be food, water, cover, and living space.
Haul Road	A road used by large trucks to haul ore and overburden from an open pit mine to other locations.
Hydrology	The science that relates to the water of the earth.
Hydrostratigraphy	The science of the arrangement of rock strata and their interrelation to water.

Impact	Influence or effect; a modification of the environment.
Impoundment	A body of water formed by the accumulation of water in a reservoir or other storage area.
Infiltration	The movement of water or some other fluid into the soil through pores or other openings.
Intermittent Stream	A stream that runs water in most months, but does not contain water year-round.
Intrusive rock	Igneous rock formed within surrounding rock as a result of magma intrusion.
Irretrievable	Applies to losses of production, harvest, or commitment of renewable natural resources. For example, some or all of the timber production from an area is irretrievably lost during the time an area is used as a winter sports site. If the use changes, timber production can be resumed. The production lost is irretrievable, but the act is not irreversible.
Irreversible	Applies primarily to the use of nonrenewable resources, such as minerals or cultural resources, or to those factors that are renewable only over long time spans, such as soil productivity. Irreversible also includes loss of future options.
Jurisdictional wetlands	Areas inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.
Key Observation Point (KOP)	Selected points from which a BLM visual resource assessment is conducted. KOPs are typically along commonly traveled routes, critical viewpoints (e.g., communities, crossings, or observation areas) or at typical or representative viewing points.
Lamprophyre	A group of dark-colored, porphyritic igneous rocks characterized by phenocrysts of mafic minerals (especially biotite, hornblende, and pyroxene) in a fine-grained groundmass of the same mafic minerals plus light-colored minerals such as feldspars.
Landform	A term used to describe the many types of land surfaces that exist as the result of geologic activity and weathering, e.g., plateaus, mountains, plains, and valleys.

Latite	A porphyritic rock having plagioclase and potassium feldspar present in nearly equal amounts of phenocrysts, little or no quartz, and a finely crystalline to glassy groundmass; the extrusive equivalent of monzonite.
Lead Agency	The public agency(s) that has (have) the principal responsibility for carrying out or approving a project.
Maximum Credible Earthquake (MCE)	The largest rationally conceivable earthquake that could occur in a particular area.
Mil	1/1,000 inch
Mineralization	Process by which minerals are introduced into a rock, resulting in an economically valuable or potentially valuable deposit.
Mitigation	Actions to avoid, minimize, reduce, eliminate, replace, or rectify the impact of a management practice or activity.
National Environmental Policy Act (NEPA)	An Act passed in 1969 declaring a national policy which will encourage productive and enjoyable harmony between humankind and the environment, to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of humanity, to enrich the understanding of the ecological systems and natural resources important to the Nation, and to establish a Council on Environmental Quality. A principal component of NEPA is the requirement to conduct EAs and EISs.
100-year flood	A flood with a magnitude that may occur once every 100 years.
100-year, 1-hour Precipitation Event	The amount of precipitation that would fall during a 1-hour period at an occurrence rate of approximately once every 100 years.
Oreodont	A prehistoric sheep-sized herbivore that lived during the Eocene period of geologic time.
Overburden	Loose or consolidated rock material that overlies a mineral deposit and must be removed prior to mining.
Oxidation	The process of combining with oxygen.
Oxide	A mineral compound of oxygen with one or more metallic elements.
Paleontology	The science that deals with the life of past geological ages through the study of the fossil remains of organisms.

Paleozoic	Span of time from end of Precambrian to beginning of Mesozoic ranging from about 570 million to 250 million years ago.
Particulate(s)	Minute, separate particles, such as dust or other air pollutants.
Pedon	The vertical profile of soil in place, typically from the surface to a depth of five feet or bedrock, whichever is shallower.
pH	The measure of acidity or alkalinity of a solution.
Phenocryst	Relatively large, conspicuous crystal in a porphyritic rock.
Physiographic province	Region in which all parts have similar geologic structure and climate and whose landforms differ significantly from those of other regions.
Piezometer	A device for measuring moderate groundwater pressures.
Porphyry intrusion	Igneous rock containing phenocrysts in a fine-grained, sugary-textured groundmass.
Potentiometric Surface	The surface to which water in an aquifer would rise by hydrostatic pressure.
Precambrian	About 90 percent of geologic time more than 2.5 billion years old; precedes Paleozoic.
Probable Maximum Flood	The greatest flood that may reasonably be expected, taking into account all pertinent conditions of location, meteorology, hydrology, and terrain. It is an extremely large flood, likely to occur at rare intervals, but it may occur in any year. It is suited for the safe design of major structures on a stream. The PMF is estimated from the PMP by hydrologic techniques.
Probable Maximum Precipitation	The critical depth-duration-area rainfall relationship for a given area during the seasons of the year which would result from a storm containing the most critical meteorological conditions considered probable of occurrence. The estimates represent the best judgment of the meteorologists of the realistic upper limit of precipitation that can occur.
Quaternary	The second period of the Cenozoic era, following the Tertiary; began 2 to 3 million years ago and extends to the present.
Raptor	A bird of prey.

Record of Decision (ROD)	A document separate from but associated with an Environmental Impact Statement that publicly and officially discloses the responsible official's decision on the Proposed Action.
Region	A large tract of land generally recognized as having similar character types and physiographic types.
Right-of-way	Strip of land over which the powerline, access road, or maintenance road would pass.
Riparian	A type of ecological community that occurs adjacent to streams and rivers and is directly influenced by water. It is characterized by certain types of vegetation, soils, hydrology, and fauna, and requires free or unbound water or conditions more moist than that normally found in the area.
Riprap	A layer of large, broken rock placed together irregularly to prevent erosion of embankments, causeways, or other surfaces.
Runoff	Precipitation that is not retained on the site where it falls, not absorbed by the soil; natural drainage away from an area.
Scoping	A term used to identify the process for determining the scope of issues related to a proposed action and for identifying significant issues to be addressed.
Sedimentary	A type of rock resulting from consolidation of loose sediment that has accumulated in layers.
Seismicity	The likelihood of an area being subjected to earthquakes. The phenomenon of earth movements.
Species	A group of individuals of common ancestry that closely resemble each other structurally and physiologically and in nature interbreed producing fertile offspring.
Stratigraphy	Form, arrangement, geographic distribution, chronologic succession, classification, and relationships of rock strata.
Tailings	The non-economic constituents of the ground ore material that remain after the valuable minerals have been removed from raw materials by milling.
Talus	Heaps of coarse debris at the foot of cliffs and steep slopes resulting from gravity transport and weathering processes.

Tectonics	Large-scale structural features of the upper part of the earth's crust.
Telluride	A binary compound of tellurium usually with a more electropositive element or radical. Metal tellurides are sometimes regarded as alloys.
Tertiary	Span of time between 65 and 3 to 2 million years ago.
Threatened species	Any species likely to become endangered within the foreseeable future throughout all or a significant part of its range.
Tributary	A stream flowing into a larger stream or other body of water.
Upgradient	At a higher point of elevation in relation to any fixed point with regard to the direction of drainage or flow.
Visual Resource Inventory	A BLM system of determining visual values in an area by inventorying existing scenic quality, sensitivity level, and distance zones. Inventory classes of one through four are assigned.
Visual Resource Management	A BLM system of analyzing the potential visual impacts of a proposed project or activity by assessing the visual contrasts that would be created between a project and the existing landscape. The major features of form, line, color, and texture are evaluated.
Waste Rock	Rock that is removed to access precious metal-bearing ore, but does not contain enough mineral to be mined and processed at a profit.
Watershed	The entire land area that contributes water to a particular drainage system or stream.
Wetlands	Areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. BLM Manual 1737, *Riparian-Wetland Area Management*, includes marshes, shallow swamps, lakeshores, bogs, muskegs, wet meadows, estuaries, and riparian areas as wetlands.

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ACRONYMS AND ABBREVIATIONS

2D	two-dimensional
3D	three-dimensional
AAQS	Ambient Air Quality Standards
ABA	acid-base accounting
ACHP	Advisory Council on Historic Preservation
AMSL	above mean sea level
APE	Area of Potential Effect
ARD	acid rock drainage
AUM	animal unit month
B.P.	before present
BLM	Bureau of Land Management
$CaCO_3$	calcite
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm/sec	centimeters per second
CN^-	cyanide
CO	Carbon monoxide
COE	Corps of Engineers
dB	decibels
dBA	A-weighted system
dbh	diameter at breast height
DOT	Department of Transportation
EA	Environmental Assessment
EC	electric conductivity
EFPB	East Flank Pump Back
EIS	Environmental Impact Statement
EMT	Emergency Medical Technician
EPA	Environmental Protection Agency
EPB	East Pump Back
FMEA	Failure Modes and Effects Analysis
gpm	gallons per minute
GSM	Golden Sunlight Mines, Inc.
HDPE	high density polyethylene
I-90	Interstate 90
I-15	Interstate 15
IBLA	Interior Board of Lands Appeals
ISB	Intermountain Seismic Belt
KOP	key observation point
kV	kilovolt
MCE	maximum credible earthquake
MDEQ	Montana Department of Environmental Quality
MDFWP	Montana Department of Fish, Wildlife, and Parks
MDNRC	Montana Department of Natural Resources and Conservation
MDSL	Montana Department of State Lands
MEPA	Montana Environmental Policy Act
mg/l	milligrams per liter
MMRA	Metal Mine Reclamation Act
MNHP	Montana Natural Heritage Program
MOU	memorandum of understanding
MPDES	Montana Pollution Discharge Elimination System
mph	miles per hour

MPS	movement parallel sunlight block
MSDS	Material Safety Data Sheets
MSHA	Mine Safety and Health Administration
MSU	Montana State University
MTPIF	Montana Partners in Flight Committee
NAG	net acid generation
NEPA	National Environmental Policy Act
NO_2	Nitrogen dioxide
NOI	Notice of Intent
NRHP	National Register of Historic Places
O_3	Ozone
OCN^-	cyanate
PDN	Predischarge Notification
PM_{10}	Particulate matter with an aerodynamic diameter of 10 microns or less
PMF	probable maximum flood
PMP	probable maximum precipitation
POO	Plan of Operation
ppm	parts per million
PSD	Prevention of Significant Deterioration
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
RFFA	reasonably foreseeable future action
RMP	Resource Management Plan
ROD	Record of Decision
ROW	Right-of-Way
RUSLE	Revised Universal Soil Loss Equation
SAR	Soil Adsorption Ratio
SARA	Superfund Amendments and Reauthorization Act
SHPO	State Historic Preservation Office
SO_2	Sulfur dioxide
SPB	South Pump Back
SPPP	Storm water Pollution Prevention Plan
STR	sand tailings retreatment
TAA	temporary accumulation area
TDS	Total Dissolved Solids
TPQ	Threshold Planning Quantity
TSD	treatment, storage, and disposal
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USLE	Universal Soil Loss Equation
VRI	Visual Resource Inventory
VRM	Visual Resource Management
WCRM	Western Cultural Resource Management
WAD CN	weak acid dissociable cyanide
WUS	Waters of the United States
yd^3	cubic yards

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HELENA, MONTANA 59620-0901

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BLM 13
GSM
GSM
BLM 18
GSM
BLM 17
GSM
GSM
STATE 16
PRIVATE 15
PRIVATE 14
INTERIM DUMP PLAN PERMIT BOUNDARY
BLM 24
BLM
BLM
GSM
BLM
30
FUEL BAY
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GSM
EAST WASTE ROCK DUMP
GSM 21
PRIVATE 22
PRIVATE 23
PIT
BLM
PLANT SITE FACILITIES
WEST WASTE ROCK DUMP
BLM
BLM
PRIVATE
BLM 25
BLM
GSM 30
GSM
GSM 29
BUTTRESS
GSM 28
PRIVATE
PRIVATE 27
PRIVATE
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GSM

GOLDEN SUNLIGHT MINE EXPANSION

MAP I-2
EXISTING PERMITTED FACILITIES

SOURCE: GSM 1995A (MAPS OP-6, OP-12); GSM 1995B (EXHIBIT 1-1)

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BLM 13
GSM
GSM
BLM 18
GSM
BLM 17
SHEEP ROCK CREEK DIVERSION STRUCTURE
GSM
GSM
STATE 16
PRIVATE 15
PRIVATE 14
PROPOSED PERMIT BOUNDARY
INTERIM DUMP PLAN PERMIT BOUNDARY
BLM 24
BLM
BLM
GSM
BLM
20
GSM 21
PRIVATE 22
PRIVATE 23
FUEL BAY
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EAST WASTE ROCK DUMP
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PLANT SITE FACILITIES
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WEST WASTE ROCK DUMP
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PRIVATE
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BLM
GSM 29
GSM 28
PRIVATE
PRIVATE 27
PRIVATE
GSM

NOTE: Subsurface ownership is not illustrated on this map. State school trust mineral estate underlies some areas of private surface lands identified. Refer to Table II-12 and Section III.H.1 for locations.

GOLDEN SUNLIGHT MINE EXPANSION

MAP II–1

PROPOSED ACTION

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2

17
SHEEP ROCK CREEK
16
PROPOSED PERMIT BOUNDARY
SEDIMENT CONTROL BERMS
SHEEP ROCK CREEK DIVERSION STRUCTURE
PROPOSED SHEEP ROCK CREEK DIVERSION CHANNEL
SHEEP ROCK CREEK NATURAL CHANNEL
BOUNDARY

SHEEP ROCK CREEK DIVERSION STRUCTURE
PROPOSED SHEEP ROCK CREEK DIVERSION CHANNEL
SHEEP ROCK CREEK NATURAL CHANNEL
INTERIM DUMP PLAN PERMIT BOUNDARY
EAST WASTE ROCK DUMP
20
21
FUEL BAY
SEDIMENT CONTROL BERMS
SHEEP ROCK CREEK TRIBUTARY
EXISTING SURFACE DISTURBANCE
PROPOSED SURFACE DISTURBANCE
BUFFER AREAS
PROPOSED PIT EXPANSION AREA
NORTH
GOLDEN SUNLIGHT MINE EXPANSION
MAP II-2
RETURN DIVERSION ALTERNATIVE

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BLM
13
GSM
GSM
BLM
18
GSM
BLM
17
GSM
GSM
AREA B1
PRIVATE
15
PRIVATE
14
PROPOSED PERMIT BOUNDARY
INTERIM DUMP PLAN PERMIT BOUNDARY
LAND BRIDGE
BLM
24
BLM
GSM
GSM
21
PRIVATE
22
PRIVATE
23
AREA A
FUEL BAY
20
RESTRICTED DUMP AREA
AREA B2
BLM
19
GSM
EAST WASTE ROCK DUMP
PIT
PLANT SITE FACILITIES
AREA C2
WEST WASTE ROCK DUMP
BLM
BLM
GSM
PRIVATE
BLM
25
BLM
GSM
30
GSM
BLM
GSM
29
BUTTRESS
GSM
28
PRIVATE
PRIVATE
27
PRIVATE
26
GSM

NOTE: Subsurface ownership is not illustrated on this map. State school trust mineral estate underlies some areas of private surface lands identified. Refer to Table II-17 and Section III.H.1 for locations.

GOLDEN SUNLIGHT MINE EXPANSION

MAP II-3

DIVIDED DUMP ALTERNATIVE
WASTE DUMP LOCATIONS

SOURCE: GSM 1995A (MAPS OP-6, OP-12); GSM 1995B (EXHIBIT 1-1)

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4

B L M 13
G S M
G S M
B L M 18
G S M
B L M 17
SHEEP ROCK CREEK DIVERSION STRUCTURE
G S M
STATE 16
PRIVATE 15
PRIVATE 14
G S M
B L M 24
PROPOSED PERMIT BOUNDARY
INTERIM DUMP PLAN PERMIT BOUNDARY
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G S M
B L M
B L M
20
G S M 21
PRIVATE 22
PRIVATE 23
19
G.S.M
FUEL BAY
EAST WASTE ROCK DUMP
PIT
PLANT SITE FACILITIES
WEST WASTE ROCK DUMP
BLM
BLM
BLM
PRIVATE
B L M 25
B L M
G S M 30
GSM
G.S.M 29
BUTTRESS
G S M 28
PRIVATE
PRIVATE 27
PRIVATE
26
G S M

NOTE: Subsurface ownership is not illustrated on this map. State school trust mineral estate underlies some areas of private surface lands identified. Refer to Table II-20 and Section III.H.1 for locations.

GOLDEN SUNLIGHT MINE EXPANSION

MAP II-4
3:1 SLOPE ALTERNATIVE

SOURCE: GSM 1995A (MAPS OP-6, OP-12); GSM 1995B (EXHIBIT 1-1)

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Table II-24

Summary Comparison of Resource Impacts Under the Proposed Action and Alternatives

	No Action	Proposed Action	Return Diversion Alternative	Divided Dump Alternative	3:1 Slope Alternative	No Pit Pond Alternative	Partial Backfill Alternative
Geology and Minerals	Potential adverse environmental consequences resulting from ground movement include exposure of ARD generating materials in waste rock dumps and release of tailings, dissolved metals, and cyanide-bearing water from tailings impoundments into surface water and groundwater resources. Under the No Action Alternative each of these impacts has a low or remote probability of occurring.	Potential adverse environmental consequences are generally the same as for the No Action Alternative, plus the additional potential for a slope failure east of Sheep Rock Creek due to placement of the East Waste Rock Dump. This additional potential for slope failure has a moderate likelihood of exposing ARD generating materials to surface infiltration.	Same as for the Proposed Action	Impacts would vary depending on the waste rock areas selected. Impacts would be similar to the Proposed Action.	This alternative is expected to have increased mass slope stability and higher factors of safety than the Proposed Action. However, the likelihood of mass slope failure and associated environmental consequences would not change substantially from the Proposed Action.	Pit walls would have greater potential for instability than under the Proposed Action, due to increased wall height. Other impacts are the same as for the Proposed Action.	Same as for the Proposed Action.
Paleontology	No known fossil beds will be destroyed under this alternative, but access to and future study of potential fossil-bearing deposits will be restricted. Previously unidentified paleontological resources could be encountered and/or directly impacted during the course of mine operations and	Impacts would be similar to those described for the No Action Alternative, but the extent of the area affected would increase. Portions of site 24JF292 could be indirectly affected by waste rock dump operations. However, GSM has committed to avoiding the site.	Same as for the Proposed Action.	Impacts would vary depending on upon the waste rock disposal areas selected. Impacts would generally be the same as described for the Proposed Action, with additional effects for specific waste rock disposal areas selected.	Impacts would be the same as those identified under the Proposed Action, except that access to approximately 20 more acres of potential fossil-bearing deposits could be	Same as for the Proposed Action.	Same as for the Proposed Action.

					substantially from the Proposed Action.		
Paleontology	No known fossil beds will be destroyed under this alternative, but access to and future study of potential fossil-bearing deposits will be restricted. Previously unidentified paleontological resources could be encountered and/or directly impacted during the course of mine operations and reclamation. Indirect impacts could result from improved accessibility and human presence in the area. Erosion could indirectly affect site 24JF292 and other potential fossil-bearing deposits in the vicinity.	Impacts would be similar to those described for the No Action Alternative, but the extent of the area affected would increase. Portions of site 24JF292 could be indirectly affected by waste rock dump operations. However, GSM has committed to avoiding the site.	Same as for the Proposed Action.	Impacts would vary depending on upon the waste rock disposal areas selected. Impacts would generally be the same as described for the Proposed Action, with additional effects for specific waste rock disposal areas selected.	Impacts would be the same as those identified under the Proposed Action, except that access to approximately 20 more acres of potential fossil-bearing deposits could be restricted in the East Waste Rock Dump area.	Same as for the Proposed Action.	Same as for the Proposed Action.
Water Resources • Water Quality	Impacts during mining operations will be limited to the local cyanide groundwater plume associated with Tailings Impoundment No. 1 (which is contained by pumpback wells). Model estimates predict that ARD generated from the existing waste rock dumps will have impacts to groundwater quality in the vicinity of the waste rock dumps, although the time before these impacts are experienced at locations of beneficial uses is estimated to be on the order of tens to hundreds of years. Under estimated (modeled) conditions, the Water Management Plan presented in Appendix A will prevent ARD impacts downgradient from the waste rock dumps from migrating outside of the proposed mixing zone boundary (see Appendix B). Springs within the proposed mixing zone boundary are likely to be impacted by ARD, and/or by drawdown effects from the capture well system that is part of the long-term water management plan presented in Appendix A.	Impacts would be generally the same as for the No Action alternative. The incremental impact to surface water and groundwater quality from new waste rock dumps constructed under the Proposed Action and other alternatives is expected to be negligible compared to existing conditions. The proposed Water Management Plan is technically feasible and can prevent ARD impacts to downgradient beneficial uses. The diversion of Sheep Rock Creek into the Conrow Creek drainage could increase erosion and sedimentation in the Conrow Creek channels.	Same as for the Proposed Action, except the potential impacts to Conrow Creek would be eliminated, and increased erosion could occur in the unnamed tributary to Sheep Rock Creek from the return diversion.	Impacts would generally be the same as for the Proposed Action, but under this alternative the time period before ARD impacts occur on the west side of Bull Mountain could be shortened if the dump configuration chosen allows for more waste rock placement on the West Waste Rock Dump. The groundwater capture and treatment system can prevent ARD impacts to downgradient beneficial uses. The erosional impacts from diverting Sheep Rock Creek would be avoided.	Same as for the Proposed Action.	Same as for the Proposed Action.	Same as for the Proposed Action.

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Table II-24 (Continued)

	No Action	Proposed Action	Return Diversion Alternative	Divided Dump Alternative	3:1 Slope Alternative	No Pit Pond Alternative	Partial Backfill Alternative
* Water Quantity	Impacts to water quantity both during mine operations and after closure will likely be limited to reduced spring flows in Steppan and Steppan Original Springs as a result of pit dewatering. Long-term impacts may be greater than operational impacts because the groundwater system around the pit may take decades to equilibrate. A monitoring and spring enhancement plan may be necessary to avoid long-term impacts to springs.	Impacts would generally be the same as for the No Action Alternative, but more severe because of additional pit dewatering and a lower elevation pit bottom during operations. Under a "worst-case" analysis Steppan and Steppan Original Springs would cease to flow, and Rattlesnake and Bunkhouse Springs would have diminished flows. A monitoring and spring enhancement plan may be necessary to avoid long-term impacts to springs.	Same as for the Proposed Action.	Same as for the Proposed Action.	Same as for the Proposed Action.	Impacts would generally be the same as for the Proposed Action, but the adverse effects of pit dewatering on seeps and springs would be most severe under this alternative due to the long-term groundwater elevation being maintained at the pit bottom.	Impacts would be the same as the Proposed Action because pit water elevations would need to be maintained below the 5,050 foot elevation to protect groundwater.
Soils	Areas not revegetated will have a long-term loss of soil development. Areas revegetated will have a change in soil structure, texture, and rock fragment percentage due to blending during soil salvage and replacement operations. Revegetation methods are designed to minimize potential erosion. Heavily-compacted areas will be graded and ripped to alleviate loss of aeration, water permeability, and water storage capacity. Soil microbial activity will be reduced due to stockpiling.	Impacts same as for No Action with the addition of 627 acres of soil disturbance.	Impacts same as for the Proposed Action with the addition of 2.5 acres of soil disturbance.	Same as for the Proposed Action with additional acres of soil disturbance, depending on which waste rock dumps are constructed.	Same as for the Proposed Action with the addition of 114 acres of soil disturbance.	Same as for the Proposed Action.	Same as for the Proposed Action.

	change in soil structure, texture, and rock fragment percentage due to blending during soil salvage and replacement operations. Revegetation methods are designed to minimize potential erosion. Heavily-compacted areas will be graded and ripped to alleviate loss of aeration, water permeability, and water storage capacity. Soil microbial activity will be reduced due to stockpiling.		the addition of 2.5 acres of soil disturbance.	depending on which waste rock dumps are constructed.	acres of soil disturbance.		
Reclamation	Waste rock dumps, tailings facilities, plant area, borrow areas, water treatment plant, and buffer zones will be completely revegetated. Reclamation activities in the pit will occur on benches suitable for revegetation, and on portions of the pit highwall containing potential wildlife habitat.	Same as for No Action with an additional 577 acres revegetated. There would be 58 acres added to the pit dimensions which would not be revegetated.	Same as for the Proposed Action with an additional 2.5 acres revegetated.	Same as for the Proposed Action with additional acres revegetated, depending on which waste rock dumps are constructed.	Same as for the Proposed Action with an additional 114 acres revegetated. A possible higher success rate for revegetation efforts could be expected for 3:1 slopes due to increased water infiltration and decreased erosion.	Same as for the Proposed Action.	Same as for the Proposed Action with an additional 235 acres revegetated.
Vegetation	Approximately 2,336 total acres of vegetation will be removed, of which 2,128 acres will be revegetated, and 208 acres will not be revegetated.	An additional 627 acres of vegetation would be removed. Approximately 2,964 total acres would be removed, of which 2,705 acres would be revegetated, and 259 acres would not be revegetated.	Same as for the Proposed Action plus 2.5 additional acres of disturbance to the mixed shrub/grassland community type. An additional 2.5 acres would be revegetated.	An additional 407 acres of vegetation would be removed under the minimum disturbance scenario. An additional 600 acres would be removed under the maximum disturbance scenario. The same areas would not be revegetated as under the Proposed Action.	Same as for the Proposed Action with an additional 114 acres removed. Approximately 3,079 total acres of vegetation would be removed, of which 2,819 acres would be revegetated and 259 acres would not be revegetated.	Same as for the Proposed Action.	Same disturbance acreage as the Proposed Action. An additional 235 acres of disturbance would be revegetated, leaving only 24 acres not revegetated.
Wetlands and Waters of the U.S. (WUS)	Past disturbance includes approximately 0.06 acre of wetland WUS and 2.5 acres of non-wetland WUS. An additional 0.6 acre of fill to non-wetland WUS will occur through Interim Dump Plan activities (total of 3.1 acres). Minor to moderate spring flow reductions are projected to occur; reduced spring flows will likely reduce the areal extent of wetland vegetation present and potentially affect species diversity.	An additional 1.8 acres of non-wetland WUS would be impacted (total of 4.9 acres). No wetland WUS would be filled. Greater spring flow reductions would occur than under the No Action, resulting in greater impacts on the areal extent of wetlands and species diversity. Potential ceased flow at Steppan and Steppan Original Springs could eliminate these associated wetlands.	Same as for the Proposed Action.	Similar to the Proposed Action. Under the minimum disturbance scenario, 0.71 acre WUS would be disturbed; under the maximum disturbance scenario, 0.94 acre WUS would be disturbed. The actual WUS affected would depend on the waste rock areas selected and could be greater or less than these scenarios. See Table IV-14 for a list of WUS affected by waste rock area.	An additional 2.3 acres of non-wetland WUS would be impacted (total of 5.4 acres).	Same as for the Proposed Action.	Same as for the Proposed Action.

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Table II-24 (Continued)

	No Action	Proposed Action	Return Diversion Alternative	Divided Dump Alternative	3:1 Slope Alternative	No Pit Pond Alternative	Partial Backfill Alternative
Wildlife	Habitat removal and disturbance has resulted in loss of small mammals, bird nestlings, and reptiles; displacement of medium-sized mammals, adult birds, and some big game animals; habitat fragmentation; and increased competition of displaced animals on adjacent areas. Some springs could experience reduced flows, potentially reducing available surface water sources for wildlife. Bat and avian species could potentially come into contact with poor quality water in the pit lake. Disturbance will reduce long-term diversity of habitats. Successful revegetation will restore habitat and minimize long-term impacts. Long-term ARD from the waste rock dumps could adversely impact the water quality in several area springs.	Similar to impacts under No Action, with continued loss and displacement of species and fragmentation of habitats occurring on the 627 additional acres disturbed. Disturbance of shafts, adits, or other underground workings could cause a loss of roosting sites and habitat for sensitive bat species. Proposed activities could result in short-term habitat loss for breeding and foraging raptors. Grassland habitat removal could cause a loss of habitat and/or loss of the year's reproductive potential for migratory birds. A greater potential for flow reduction in area springs would occur than under the No Action. A larger pit lake would increase the potential for bat and avian contact with poor quality pit water than under the No Action. Long-term ARD impacts would be the same as the No Action.	Same as the Proposed Action plus an additional 2.5 acres of wildlife habitat disturbed.	Similar to the Proposed Action except that less total area of previously undisturbed habitat would be disturbed. The actual area disturbed would depend on which waste rock dumps are constructed. Maintaining the Sheep Rock Creek drainage in place would benefit terrestrial species that use the drainage as a north-south movement corridor.	Same as the Proposed Action plus an additional 114 acres of wildlife habitat disturbed.	Same as the Proposed Action with the exception that potential adverse impacts to waterfowl and bats from contact with poor quality water in the pit lake would be eliminated.	Same as the Proposed Action except that the additional 235 acres revegetated would further minimize long-term impacts to wildlife, and elimination of the pit lake would remove the potential for bat and avian contact with poor quality pit water.
Fisheries	Waste rock dump designs, retention berms, and surface water diversion structures are expected to adequately manage surface water flows to prevent short-term impacts to water quality or quantity in	Same as for the No Action Alternative.	Same as for the No Action Alternative.	Same as for the No Action Alternative.	Same as for the No Action Alternative.	Same as for the No Action Alternative.	Same as for the No Action Alternative.

	springs.	increase the potential for bat and avian contact with poor quality pit water than under the No Action. Long-term ARD impacts would be the same as the No Action.					
Fisheries	Waste rock dump designs, retention berms, and surface water diversion structures are expected to adequately manage surface water flows to prevent short-term impacts to water quality or quantity in off-site fisheries. Long-term ARD from the waste rock dumps could adversely impact aquatic life in the Jefferson River.	Same as for the No Action Alternative.	Same as for the No Action Alternative.	Same as for the No Action Alternative.	Same as for the No Action Alternative.	Same as for the No Action Alternative.	Same as for the No Action Alternative.
Threatened, Endangered, and Candidate Species	Formation of the pit lake represents a potential impact to trumpeter swans and other species that may come into contact with poor quality pit water. No other impacts beyond loss of potential habitat have occurred or are expected to occur. Reclamation will restore much of the habitat lost.	Impacts would be similar to the No Action Alternative, but would occur over a longer period of time. The additional disturbed acres do not represent limited habitat types in the region. The seven sensitive bat species would be impacted if any occupied shafts or adits are disturbed. The pit lake represents a potential impact to sensitive bat species and trumpeter swans from contact with the poor quality water.	Same as for the Proposed Action.	Same as for the Proposed Action except that the area of wildlife habitat disturbed would be different. The total area disturbed would depend on which waste rock dumps are constructed. One deep, open mine shaft in the western portion of Section 30 would be directly affected by construction of Area C1, potentially impacting sensitive bat species.	Same as for the Proposed Action plus 114 additional acres of wildlife habitat disturbed.	Same as for the Proposed Action, except that potential adverse impacts to waterfowl and bats from contact with poor quality pit water would be eliminated.	Same as for the Proposed Action except that potential adverse impacts to waterfowl and bats from contact with poor quality pit water would be eliminated, and an additional 235 acres of wildlife habitat would be revegetated.
Air Quality	Current mining operations result in insignificant impacts to air quality. Emissions do not exceed state or federal air quality standards. GSM follows standard construction practices to minimize fugitive emissions and impacts to air quality. Emissions are expected to decrease as disturbed areas are revegetated.	Additional particulate and emissions pollution would be expected due to additional acreage disturbed. However, modeling results indicate that maximum concentrations of PM_{10}, NO_2, CO, and SO_2 would not exceed Montana or National Ambient Air Quality Standards.	Same as for the Proposed Action.	Same as for the Proposed Action.	More particulate emissions would be expected than under the Proposed Action, due to increased surface area of reclaimed land and amount of soil needed for reclamation. However, emissions would not be expected to exceed state or federal standards.	Slightly greater particulate emissions would be likely than under the Proposed Action.	Nearly double the particulate emissions of the Proposed Action would result from this alternative over time, due to activities associated with backfilling the pit. However, emissions would not be expected to exceed state or federal standards.

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Table II-24 (Continued)

	No Action	Proposed Action	Return Diversion Alternative	Divided Dump Alternative	3:1 Slope Alternative	No Pit Pond Alternative	Partial Backfill Alternative
Land Uses and Plans	Mine operations will cease in 1997 or 1998, and reclamation will proceed as per the schedule listed in Table II-6. Project area disturbed lands will be returned to their pre-mining land uses once sufficient revegetation has taken place.	Permit boundary would expand to include an additional 1,054 acres. Disturbance area would expand to include an additional 627 acres. Disturbance over state school trust lands would increase by 361 acres. A new right-of-way would be required for rerouting a microwave power line. An area of 350 to 400 acres would be disturbed or restricted from use in the Hill and Wilkerson Allotment, for a loss of 22 measurable AUMs plus some early spring pasture for private grazing. A pipeline and stock water trough would be displaced, but mitigated by other range improvements.	Same as the Proposed Action, with an additional 2.5 acres disturbed by the diversion channel. Under this alternative, the displaced stock water pipeline could be rerouted through the Sheep Rock Creek diversion channel.	Impacts would vary with waste rock areas selected. The total disturbance area would likely be less than under the Proposed Action, although the areas of state and federal lands impacted could be greater than the Proposed Action, depending on the areas selected. The permit boundary would need to be expanded beyond the area for the Proposed Action if Areas B1, B2, C1, or C2 are selected. Disturbance above state school trust subsurface lands would be substantially less than the Proposed Action if Areas C1 or C2 are selected, and would be comparable or slightly greater if Areas B1 or B2 are selected. Grazing impacts would depend on the areas selected. Areas C1 and C2 would impact the Bull Mountain Allotment. Areas A, B1, B2,	Same as the Proposed Action, with 114 acres additional disturbance in the East and West Waste Rock Dumps; 23 acres additional disturbance over state school trust subsurface lands, and greater disturbance in grazing allotments, including 21 acres in the Bull Mountain Allotment (3 AUMs) and 22 additional acres in the Mill and Wilkerson Allotment.	Same as the Proposed Action.	Same as the Proposed Action, except that all benches in the pit would be capped with rock and soil and revegetated.

		grazing. A pipeline and stock water trough would be displaced, but mitigated by other range improvements.		state school trust subsurface lands would be substantially less than the Proposed Action if Areas C1 or C2 are selected, and would be comparable or slightly greater if Areas B1 or B2 are selected. Grazing impacts would depend on the areas selected. Areas C1 and C2 would impact the Bull Mountain Allotment. Areas A, B1, B2, and the land bridge would impact the Hill and Wilkerson Allotment. Rerouting requirements for the displaced microwave power line would depend on the areas selected.	acres in the Mill and Wilkerson Allotment.		
Visual Resources	No additional impacts to visual resources will occur. Reclamation of current disturbances will proceed following mine closure in 1997. Recontouring and revegetating slopes will reduce visual contrasts, but large scale forms such as the pit highwall, pit terraces, and waste rock dumps will remain. Reclamation will reduce contrasts to a level consistent with the suggested VRM Class III rating.	Additional disturbance would increase the physical extent of visual contrast with the natural environment and increase the areas requiring rehabilitation under the suggested VRM Class III rating.	Same as for the Proposed Action.	Impacts would depend on the areas selected for waste rock disposal. Contrasts resulting from the East Waste Rock Dump expansion under the Proposed Action would not occur. However, contrasts visible from KOP 2 would increase if Areas B1 or B2 are constructed. Contrasts visible from KOP1 would increase if Areas C1 or C2 are constructed. Contrasts remaining following reclamation would be greater than the Proposed Action with construction of facilities more prominent in the landscape (Areas B1, B2, or C1).	Same as for the Proposed Action except that visual contrasts following reclamation would be reduced in the East Waste Rock Dump area, as 3:1 slopes would blend more naturally with the landscape in this area. Visual contrasts would be slightly greater in the West and South Waste Rock Dump areas. Impacts in relation to the VRM classification would be the same as the Proposed Action.	Same as for the Proposed Action.	Same as the Proposed Action during mine operation, and less following reclamation. Contrasts visible from KOPs 1 and 2 would be less than under the Proposed Action, as the size of the waste rock dumps would be reduced and some of the pit contours partially restored.
Noise	Noise will continue at current levels until the end of mine operations in 1997. Noise will continue at a reduced level through the reclamation period.	Noise would not increase with implementation of the Proposed Action and would continue at current levels until end of mine life in 2006. Noise would continue at reduced levels during reclamation.	Same as the Proposed Action.	Noise impacts would vary depending on which areas are selected for waste rock disposal. Selection of Areas C1 or C2 would increase noise impacts for residences near the west side of the mine. Selection of Areas B1 or B2 would increase noise impacts for residences near the east side of the mine.	Same as the Proposed Action.	Same as the Proposed Action.	Noise impacts would be the same during mine operation and greater during reclamation due to dumping, hauling, and grading activities associated with backfilling the pit.

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Table II-24 (Continued)

	No Action	Proposed Action	Return Diversion Alternative	Divided Dump Alternative	3:1 Slope Alternative	No Pit Pond Alternative	Partial Backfill Alternative
Social and Economic Resources	Loss of employment, personal income, tax revenue, and other economic benefits contributed by GSM with mine closure in 1997 or 1998. Economic benefits will continue at a reduced level through the reclamation phase.	On-going employment of mine personnel, associated community benefits of high-wage mining sector employment and income, tax revenues for the state and county, and the economic benefits of local purchases of goods and services. Phasing out of employment beginning in 2002. Reduced tax revenues and other economic benefits through the reclamation phase.	Same as the Proposed Action.	Same as the Proposed Action.	Same as the Proposed Action.	Same as the Proposed Action.	Same as the Proposed Action, with additional employment continuing through the reclamation period for backfilling activities.
Hazardous Materials and Wastes							
• Hazardous Waste Generation	All hazardous materials and wastes are transported to and from the site by DOT and EPA registered and approved transporters. There is no on-site disposal of hazardous waste or storage for more than 90 days. Current mining operations will cease as reclamation commences.	This action would extend the life of the project but not affect any of the processes currently performed on site. The rate of hazardous material generation would remain unchanged until mine closure in 2006.	Same as for the Proposed Action.	Same as for the Proposed Action.	Same as for the Proposed Action.	Same as for the Proposed Action.	Same as for the Proposed Action.
• Hazardous Material Spills	Spills could occur, associated with truck deliveries of process chemicals and fuels. The number of	Same as the No Action Alternative.	Same as for the Proposed Action.	Same as for the Proposed Action.	Same as for the Proposed	Same as for the	Same as for the

- Hazardous Waste Generation	All hazardous materials and wastes are transported to and from the site by DOT and EPA registered and approved transporters. There is no on-site disposal of hazardous waste or storage for more than 90 days. Current mining operations will cease as reclamation commences.	This action would extend the life of the project but not affect any of the processes currently performed on site. The rate of hazardous material generation would remain unchanged until mine closure in 2006.	Same as for the Proposed Action.	Same as for the Proposed Action.	Same as for the Proposed Action.	Same as for the Proposed Action.	Same as for the Proposed Action.
- Hazardous Material Spills	Spills could occur, associated with truck deliveries of process chemicals and fuels. The number of releases expected during the project life ranges between 0.001 and 0.004, depending on the chemical or fuel. Emergency response actions are expected to contain and clean up any spills. Chemicals and fuels kept in storage are contained, minimizing spill impacts.	Same as the No Action Alternative.	Same as for the Proposed Action.	Same as for the Proposed Action.	Same as for the Proposed Action.	Same as for the Proposed Action.	Same as for the Proposed Action.
Cultural Resources	Sites 24JF227, 228, and 229 have been previously impacted. Eight sites potentially could be indirectly affected (24JF292 [Sheep Rock], 712, 717, 762, 942, 944, 1095, 1106). Any disturbed resources should be mitigated according to site-specific plans formulated in consultation with GSM, BLM, MDEQ, MDNRC, the SHPO, the ACHP, and any other identified interested parties.	Six sites would be directly affected (the 3 previously impacted sites identified under the No Action Alternative, plus sites 24JF942, 944, and 1095). Six sites would be indirectly affected (24JF292, 712, 717, 762, 1092, 1106). The same mitigation described for the No Action would apply to the Proposed Action.	Same as for the Proposed Action.	Same as for the Proposed Action, with additional sites disturbed in the following areas: Area A: none; Area B1: direct impact to site 24JF296; Area B2: none; Area C1: direct impact to site 24JF1073; indirect impact to 24JF1123; Portions of Sections 36 would require Class III surveying; Area C2: indirect impact to site 24JF1063.	Same as for the Proposed Action, with potential indirect impacts to one additional site (24JF1073).	Same as for the Proposed Action.	Same as for the Proposed Action.
Native American Concerns	No comments from Native American groups notified by the BLM have been received. No traditional use or religious sites have been identified within the existing permit boundaries; however, the SHPO concurred with BLM's recommendation to consult with Native Americans on sites 24JF942 and 944. Additional study and consultation for sites 24JF942 and -944 have lead to BLM recommendation that the sites are not eligible to the NRHP.	No impacts to cultural properties of significance to Native Americans are expected to occur. No comments from Native American Tribal groups have been received to date.	Same as for the Proposed Action.	Same as for the Proposed Action, with additional impacts, depending upon the waste rock areas chosen. Selection of Area C1 could result in direct impacts to talus pit site 24JF1073, and indirect impacts to talus pit site 24JF1123 (both protected under patent covenant). Selection of Area C2 could result in indirect impacts to talus pit site 24JF1063 (another protected site).	Same as the Proposed Action except that indirect impacts to site 24JF1073 (protected under patent covenant) could occur.	Same as the Proposed Action.	Same as the Proposed Action.

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Table II-24 (Continued)

	No Action	Proposed Action	Return Diversion Alternative	Divided Dump Alternative	3:1 Slope Alternative	No Pit Pond Alternative	Partial Backfill Alternative
Regulatory Restrictions Analysis	Extremely restrictive. Resulting in a substantial decrease in GSM's property value, and an almost total loss of anticipated future economic benefits.	Applicant Proposed Action.	More restrictive than the Proposed Action. Would cost $146,300 more than the Proposed Action.	Very restrictive. Many direct and indirect costs would be incurred. Large expenditures would be required (ranging from $1,275,000 for Area A to $18,368,000 for Area C2). Total expenditures would depend on the areas selected. Minimum disturbance scenario: $18,368,000. Maximum disturbance scenario: $15,675,000.	More restrictive than the Proposed Action. Additional costs are estimated at $13,263,400.	More restrictive than the Proposed Action. Additional costs are estimated at $371,000 to $446,000. Additional costs for chemicals in the treatment process cannot be estimated at this time.	Very restrictive. Additional expenditures of approximately $32,500,000 would be required. The economic feasibility is currently being evaluated

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Ybs
CURRENT PERMIT BOUNDARY
Kev
Kil
Yl
Corridor Fault
B'
A
19
20
21
22
23
24
New Deal Fault
Lone Eagle Fault
Shamrock Fault
Golden Sunlight or Indian Valley Fault
Proposed Ultimate Pit Boundary
Kmhbx
A'
Plant Area
Q-T
31,000 N.
25,000 N.
Q–T Quaternary and Tertiary Deposits
Kil Cretaceous Latite
Kev Cretaceous Elkhorn Volcanics
Kmhbx Cretaceous Mineral Hill Breccia
Ybs Precambrian Bull Mountain Shale
Yl Precambrian LaHood Formation

GOLDEN SUNLIGHT MINE EXPANSION

MAP III-1

SURFACE GEOLOGY

GOLDEN SUNLIGHT MINING AREA

SOURCE: GSM 1995B (FIG. 3.12-1)

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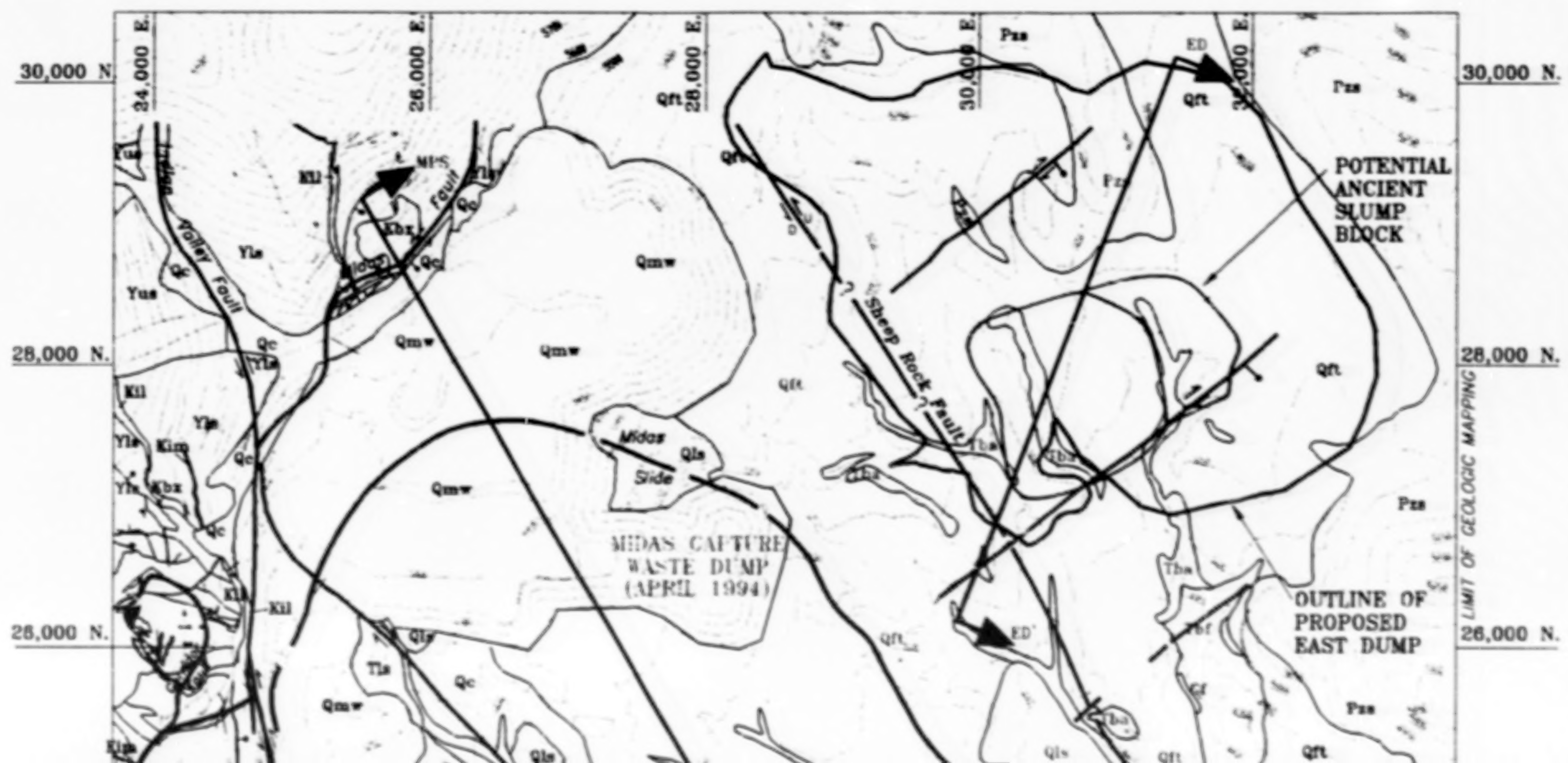
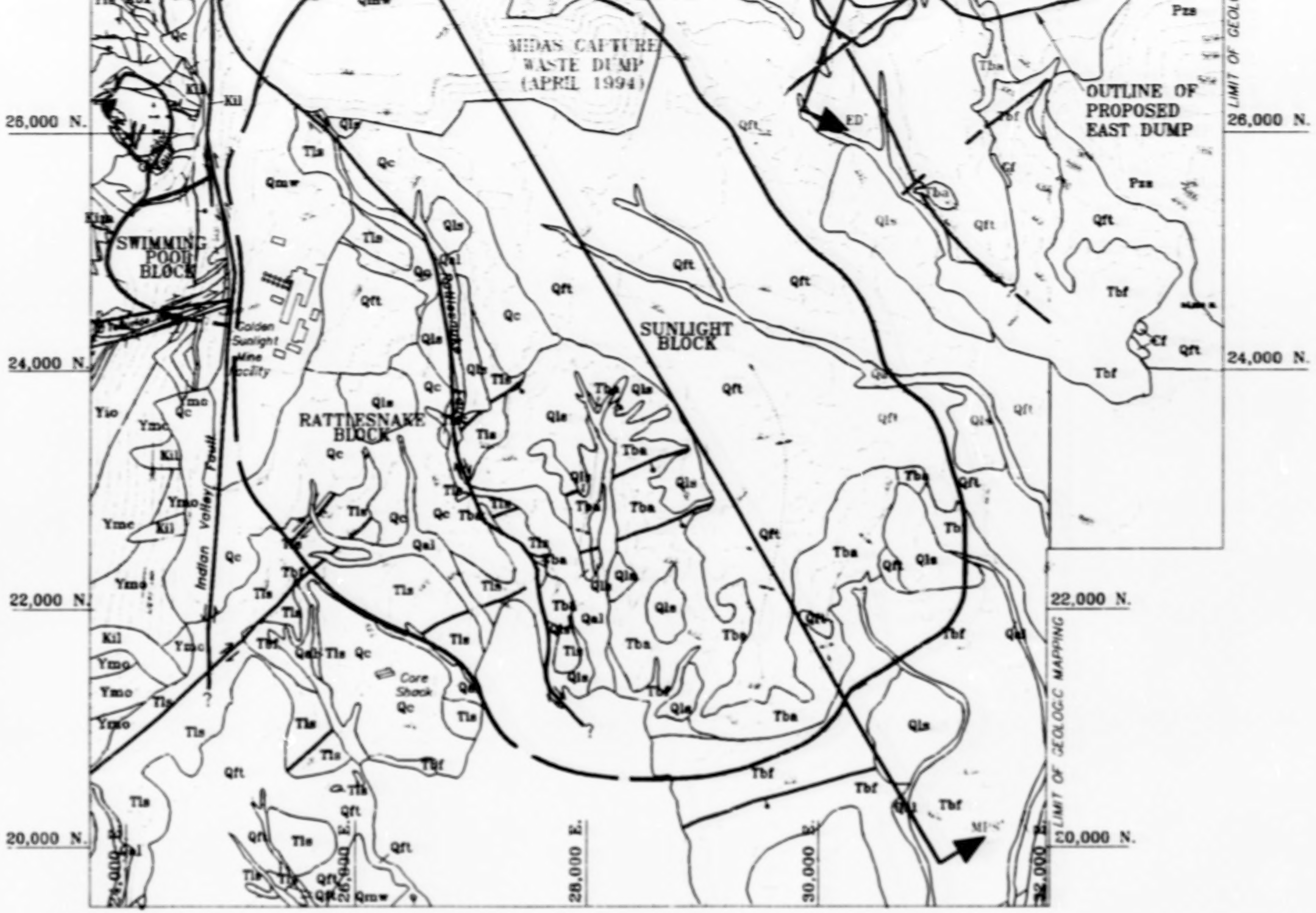


DESCRIPTION OF MAP UNITS

CENOZOIC	Quaternary	Holocene	Qmw	*Mine waste materials*
			Qal	*Alluvium*
			Qf	*Alluvial fan deposits*
		Pleistocene	Qls	*Landslide and debris flow deposits*
			Qt	*Alluvial terrace deposits*
			Qc	*Colluvial deposits; includes some alluvium*
			Qft	*Alluvial fan – terrace deposits*
	Tertiary	Miocene	Tls	*Landslide and debris flow deposits*
		Oligocene	Tba	*Bozeman Group; alluvial fan facies*
			Tbf	*Bozeman Group; fluvial facies*
MESOZOIC	Cretaceous		Kim	*Mafic intrusive rocks; undifferentiated*
			Kbx	*Breccia; undifferentiated (includes hydrothermal & intrusion breccia)*
			Kmhbx	*Mineral Hill Breccia*
			Kld	*Quartz monzodiorite*
			Kll	*Porphyritic pheno-latite (whole rock composition: rhyolite)*
OZOIC (Pzs)	Miss.		Mml	*Lodgepole Formation (Madison Group)*
	Devonian		Dt	*Three Forks Formation*
			Dj	*Jefferson Formation*
			Dm	*Maywood Formation*
			Cpl	*Pilgrim Formation*



MESOZ	Cretace	Kmhbx	*Mineral Hill Breccia*
		Kld	*Quartz monzodiorite*
		Kll	*Porphyritic pheno-latite (whole rock composition: rhyolite)*
PALEOZOIC (Pzs)	Miss.	Mml	*Lodgepole Formation (Madison Group)*
	Devonian	Dt	*Three Forks Formation*
		Dj	*Jefferson Formation*
		Dm	*Maywood Formation*
	Cambrian	Cpl	*Pilgrim Formation*
		Cp	*Park Formation*
		Cm	*Meagher Formation*
		Cw	*Wolsey Formation*
		Cf	*Flathead Formation*
PROTEROZOIC		Yb	*Bull Mountain Group (informal); undifferentiated Ysh, Yus, Yls*
		Ysh	*Bull Mountain Group (informal); shelf shales and siltstones*
		Yus	*Bull Mountain Group (informal); upper slope shales*
		Yls	*Bull Mountain Group (informal); lower slope siltstones and shales*
		Yscb	*LaHood Formation; submarine canyon black cherty shale*
		Yscs	*LaHood Formation; submarine canyon sulfidic shale*
		Yic	*LaHood Formation; inner fan channel sandstone*
		Yio	*LaHood Formation; inner fan overbank black shale*
		Yioi	*LaHood Formation; inner fan overbank shales with limestone interbeds*
		Ymc	*LaHood Formation; middle fan channel sandstone*
		Ymo	*LaHood Formation; middle fan overbank sandstone and shale*
		Yof	*LaHood Formation; outer fan sandstone and shale*
		Yff	*LaHood Formation; fan fringe shale and sandstone*
		Ybp	*LaHood Formation; basin plain black shale*

LEGEND

Geologic Contact

Fault; dotted where concealed; strike slip movement

Fault; dotted where concealed; dip slip movement

U D *Fault; dotted where concealed; reverse slip movement*

Vein; dotted where concealed

Axial trace of plunging anticline

Axial trace of plunging syncline

Outline of ground movement

NORTH

GOLDEN SUNLIGHT MINE EXPANSION

MAP III-2

SURFICIAL GEOLOGY
VALLEY-FILL SEDIMENTS

SOURCE: COMPILED FROM - GOLDER ASSOC. LTD. 1995A (FIG. 4); 1995I (FIGS. 1 AND 2)

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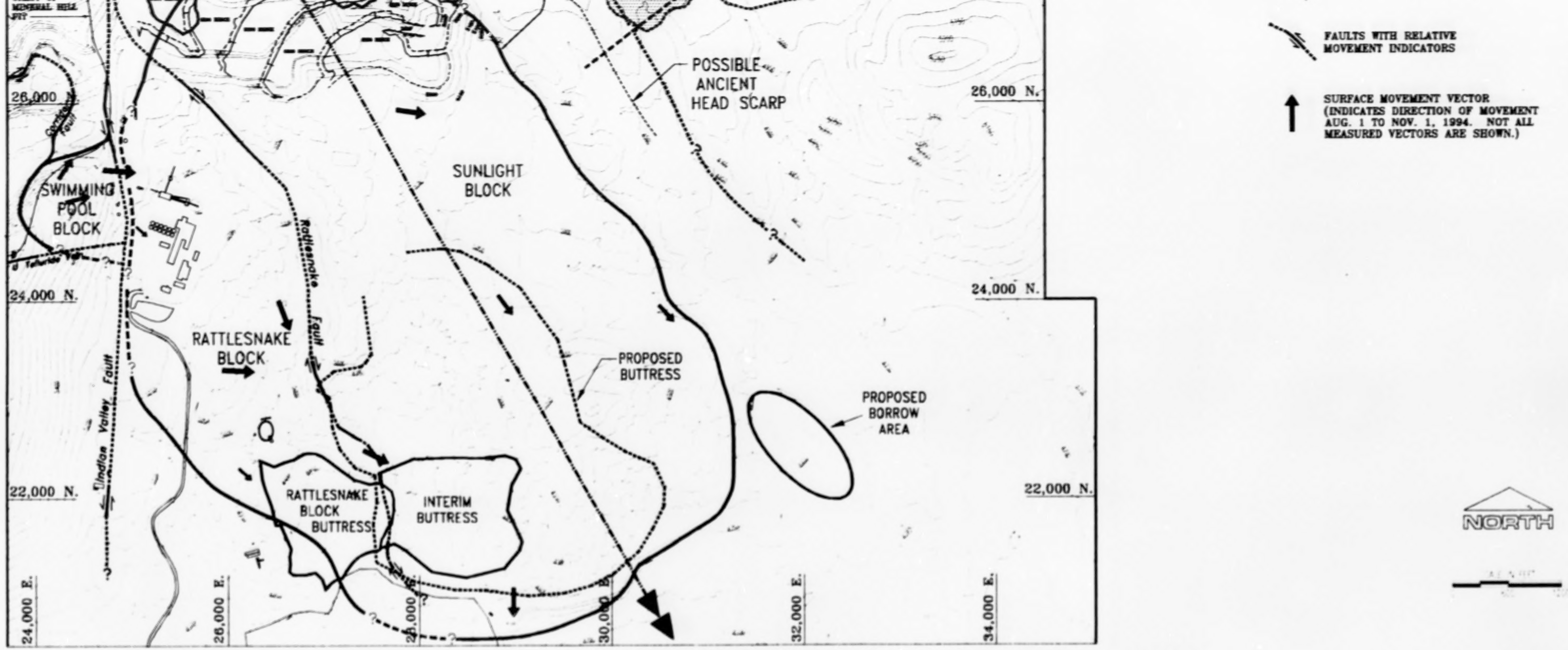
24,000 E.
26,000 E.
28,000 E.
30,000 E.
32,000 E.
34,000 E.
Approx. 5500
Approx. 5620
Approx. 5360
MPS
MIDAS SLUMP
Midas Fault
Indian Valley Fault
APPROX. TOE OF INTERIM EAST DUMP
Sheep Rock Fault
SHEEP CREEK INFILL
POTENTIAL ANCIENT SLUMP BLOCK
28,000 N.
PROPOSED EAST DUMP OUTLINE
CREST OF MINERAL HILL PIT
POSSIBLE ANCIENT HEAD SCARP
26,000 N.
SUNLIGHT
LEGEND
OUTLINE OF GROUND MOVEMENT
FAULTS WITH RELATIVE MOVEMENT INDICATORS
SURFACE MOVEMENT VECTOR (INDICATES DIRECTION OF MOVEMENT AUG. 1 TO NOV. 1, 1994. NOT ALL MEASURED VECTORS ARE SHOWN.)



GOLDEN SUNLIGHT MINE EXPANSION

MAP III-3

GROUND MOVEMENT AND RELATED FEATURES

SOURCE: COMPILED FROM – GOLDER ASSOC. LTD. 1995G (FIG. 1); 1995I (FIGS. 1 AND 2)

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14

6000
LIMITS OF MIDAS SLUMP
Qls
PRE-UNLOADING WASTE ROCK SURFACE

LIMITS OF MIDAS SLUMP
Qls
ESTIMATED LOCATION OF HEAD OF BLOCK SLIP
PRE-UNLOADING WASTE ROCK SURFACE
POST-UNLOADING WASTE ROCK SURFACE
TERTIARY GRAVELS AND SANDS (Tg and Ts)
PROPOSED BUTTRESS
EXISTING GROUND SURFACE
BEDROCK
T
A
Tba
BLOCK SLIP SURFACE
BOZEMAN ALLUVIAL FACIES (Tba)
MIDAS FAULT
BOZEMAN FLUVIAL FACIES (Tbf)
ELEVATION (FT)
6000
5500
5000
4500
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
DISTANCE (FT)

GOLDEN SUNLIGHT MINE EXPANSION

FIGURE III-4
MOVEMENT PARALLEL SUNLIGHT BLOCK
CROSS-SECTION MPS-MPS'

SOURCE: MODIFIED FROM - GOLDER ASSOC. LTD. 1995A (FIG. 10)

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21,000 E.
26,000 E.
31,000 E.
36,000 E.
30,000 N.
25,000 N.
GDW-1
Sheep Rock Spring
Beaver Springs
East Dump Complex
Midas Spring
Sheep Rock Draw
Drainage System
St. Paul Gulch
Pit Pond/ Sump
Highwall Springs
Open Pit
Ohio Adit
Plant Site
Rattlesnake Gulch
Main Access
West Dump Complex
Arkose Valley
CONTOUR INT.
CONTOUR INT.

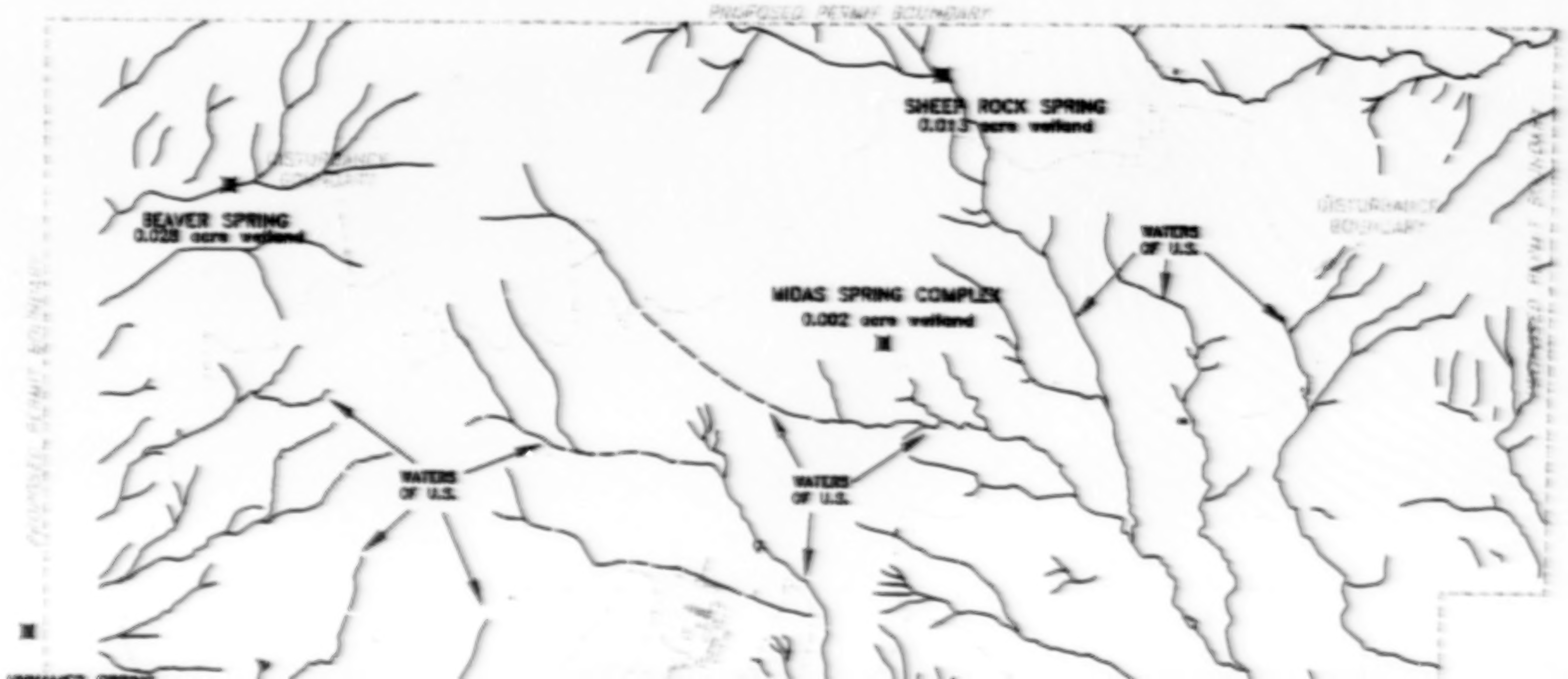
GOLDEN SUNLIGHT MINE EXPANSION

MAP III-4

HYDROLOGIC FEATURES AND GSM WATER RESOURCES MONITORING SITES

SOURCE: GSM 1995 b APPENDIX 3.5-1 EXHIBIT 1

BEST COPY AVAILABLE


PROPOSED PERMIT BOUNDARY
SHEEP ROCK SPRING
0.013 acre wetland
DISTURBANCE BOUNDARY
BEAVER SPRING
0.028 acre wetland
WATERS OF U.S.
DISTURBANCE BOUNDARY
MIDAS SPRING COMPLEX
0.002 acre wetland
PROPOSED PERMIT BOUNDARY
PROPOSED PERMIT BOUNDARY
WATERS OF U.S.
WATERS OF U.S.

WATERS OF U.S.
WATERS OF U.S.
UNNAMED SPRING wetland area unknown
ARKOSE VALLEY SPRING 0.005 acre wetland
SUNLIGHT SPRING 0.012 acre wetland
RATTLESNAKE SPRINGS 0.008 acre wetland
BUNKHOUSE SPRING 0.188 acre wetland
NORTH BORROW SPRINGS 0.040 acre wetland
STEPPAN SPRING 0.010 acre wetland
DISTURBANCE BOUNDARY
WATERS OF U.S.
STEPPAN ORIGINAL SPRING 0.002 acre wetland
WEST TAILING WETLAND 0.101 acre wetland
JEFFERSON SLOUGH FLOODPLAIN DEPRESSION 0.070 acre wetland
JEFFERSON SLOUGH BANK FRINGE WETLAND 4.920 acre wetland
GRAVEL QUARRY FRINGE WETLAND 0.010 acre wetland
NON-WETLAND
LEGEND
DISTURBANCE BOUNDARY
PERMIT BOUNDARY
WATERS OF THE U.S.
SECTION BOUNDARIES
N
W
E
SCALE IN FEET
0
1500
3000

GOLDEN SUNLIGHT MINE EXPANSION

MAP III-6

WETLANDS AND WATERS OF THE U.S.

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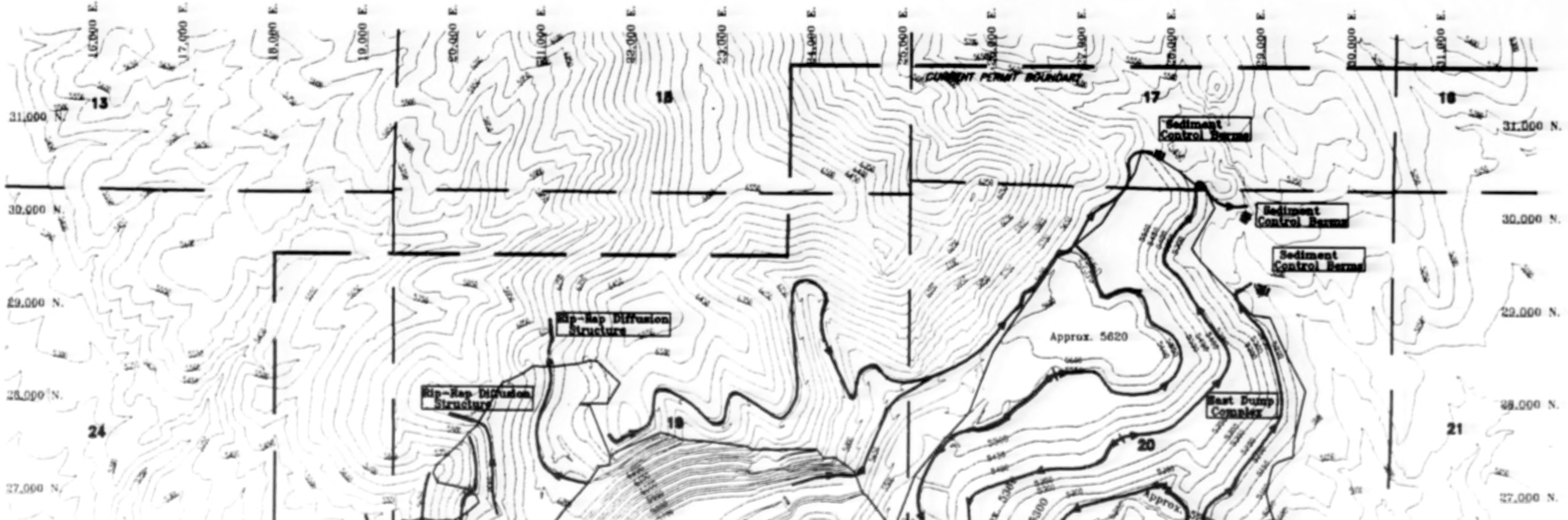
17

TAYLOR 1982a
14
13
18
17
16
15
TAYLOR 1983
MILLER 1980a
PETERSON 1991
PETERSON 1996
PETERSON & MEHLS 1994
TAYLOR 1982b
HERBORT 1985
23
24
19
20
21
22
PROJECT AREA
TAYLOR 1985

GOLDEN SUNLIGHT MINE EXPANSION

MAP III-7
CLASS III CULTURAL RESOURCES
SURVEY BOUNDARIES


16,000 E.
17,000 E.
18,000 E.
19,000 E.
20,000 E.
21,000 E.
22,000 E.
23,000 E.
24,000 E.
25,000 E.
26,000 E.
27,000 E.
28,000 E.
29,000 E.
30,000 E.
31,000 E.
CURRENT PERMIT BOUNDARY
13
18
17
16
31,000 N.
30,000 N.
29,000 N.
28,000 N.
27,000 N.
Sediment Control Berms
Sediment Control Berms
Sediment Control Berms
Rip-Rap Diffusion Structure
Rip-Rap Diffusion Structure
Approx. 5620
East Dump Complex
24
19
20
21
Approx.

GOLDEN SUNLIGHT MINE EXPANSION

MAP IV-1

ULTIMATE INTERIM WASTE DUMP SURFACE WATER DIVERSIONS

SOURCE: GSM 1995a OP-MAP-7

BEST COPY AVAILABLE

21,000 E.
26,000 E.
31,000 E.
36,000 E.
Beneficial Use
Wildlife
Livestock
Beaver Springs
Beneficial Use
Wildlife
Livestock
EDW-1
Sheep Rock Spring
Creek
30,000 N.
30,000 N.
Sheep Rock Draw
East Dump Complex
Midas Spring
Drainage System
Pit Road/
Pit Sump
Highwall Springs
St. Paul Gulch
Open Pit
Plant Site
Ohio Adit
Rattlesnake Gulch
25,000 N.
25,000 N.
West Dump Complex
Beneficial Use
Wildlife
Potential
Beneficial Use
Unnamed Spring

GOLDEN SUNLIGHT MINE EXPANSION

MAP IV-2
BENEFICIAL USES IN GSM VICINITY

SOURCE: GSM 1995b APPENDIX 3.5-1, EXHIBIT 1

BEST COPY AVAILABLE

19,000 E.
20,000 E.
21,000 E.
22,000 E.
23,000 E.
24,000 E.
25,000 E.
26,000 E.
27,000 E.
28,000 E.
29,000 E.
30,000 E.
31,000 E.
32,000 E.
33,000 E.
PROPOSED PERMIT BOUNDARY
CURRENT PERMIT BOUNDARY
31,000 N.
30,000 N.
29,000 N.
28,000 N.
27,000 N.
13
R4W R3W
18
17
16
21
19
Sediment Control Berms
Sheep Rock Draw Diversion Channel
Sediment Control Berms
Approx. 5500
Sheep Rock Draw Collection Structure
Approx. 5360
Rip-Rap Diffusion Structure
Rip-Rap Diffusion Structure
Approx. 5620
Interim East Dump Complex
5300 Haul Road
Approx. 5200
Proposed Expansion

GOLDEN SUNLIGHT MINE EXPANSION

MAP IV–5
ULTIMATE WASTE DUMP
SURFACE WATER DIVERSIONS

SOURCE: GSM 1995b EXHIBIT 4-1

BEST COPY AVAILABLE

21